

CPWF Project Report

Companion modeling for resilient water management:
Stakeholders' perceptions of water dynamics and
collective learning at the catchment scale

Project Number 25

PN25 Governance Author Team

GREEN Research Unit, Cirad & Partners

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Program Preface:

The Challenge Program on Water and Food (CPWF) contributes to efforts of the international community to ensure global diversions of water to agriculture are maintained at the level of the year 2000. It is a multi-institutional research initiative that aims to increase water productivity for agriculture—that is, to change the way water is managed and used to meet international food security and poverty eradication goals—in order to leave more water for other users and the environment.

The CPWF conducts action-oriented research in nine river basins in Africa, Asia and Latin America, focusing on crop water productivity, fisheries and aquatic ecosystems, community arrangements for sharing water, integrated river basin management, and institutions and policies for successful implementation of developments in the water-food-environment nexus.

Project Preface:

Companion modeling for resilient water management: Stakeholders' perceptions of water dynamics and collective learning at the catchment scale.

The project specific objectives were threefold: (i) Methodological development by offering tools and a methodology for their use to enhance the capacity of expression of stakeholders' perceptions, to facilitate their collective assessment of water management problems, and to improve coordination among water users through the identification and assessment of scenarios of change leading to agreed-upon action plans, (ii) Capacity building by training a group of scientists and development officers engaged in the action-research process on this methodology and its tools to test and adapt them to their needs at key sites, (iii) Participatory construction of concrete propositions to increase water productivity. The project was implemented in the deltaic (Vietnam), medium and upper (Thailand) regions of the Mekong basin and at three contrasted sites in West central and Eastern Bhutan to analyze concrete water and land management issues at the catchment level, and stakeholders' interactions specific to these water-related problems at each site. The participatory analyses and modelling and simulation processes led to collective assessments of possible changes to increase water productivity and scenarios of (technological and/or organizational) adaptation identified by local stakeholders to reach the desired situation. At each site, these scenarios were simulated by using different types of multi-agent based modelling and simulation tools such as role-playing games associated to computer agent-based models in order to facilitate communication among diverse stakeholders, the exchange of perceptions and knowledge, and when feasible the negotiation of concrete action plans.

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LIST OF ACRONYMS AND TECHNICAL TERMS

ABM	Agent-Based Model
ARI	Advanced Research Institute
CEMAGREF	Institut de recherche en sciences et technologies pour l'environnement (France)
CORRB	Council for Renewable Natural Resource Research of Bhutan (MoAB, Bhutan)
CGIAR	Consultative Group on International Agricultural Research
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement (France)
CMU	Chiang Mai University (Thailand)
CNR	College of natural Resources (RUB, Bhutan)
ComMod	Companion Modeling (see at http://www.commod.org/en)
CORMAS	Common-pool Resources and Multi-Agent Systems (a simulation platform developed by CIRAD, see at http://cormas.cirad.fr/indexeng.htm)
CPWF	Challenge Program on Water and Food of the CGIAR
cRPG	Computer-assisted role-playing game
CTU	Cantho University, (Vietnam)
CU	Chulalongkorn University (Thailand)
DANIDA	Danish International Development Agency
DYCODEV	Comparison of development dynamics master program, Paris Ouest Nanterre La Défense University
Echel Eau	Eau, Acteurs Usages project (Agropolis International, France)
FNR	Faculty of Natural Resources (PSU, Thailand)
IDTR	Innovation for development of rural territories, Montpellier 3 University
IFWF	International Forum on Water and Food
IPE	Impact pathway evaluation
INRM	Integrated natural resource management
IRC	Institut des régions chaudes (Hot areas institute), SupAgro, Montpellier (France)
IWMI	International Water Management Institute
IWRM	Integrated water resource management
KU	Kasetsart University (Thailand)
M&E	Monitoring and evaluation
MAS	Multi-agent system
MCC	Multiple Cropping Center (CMU, Thailand)
MoAB	Ministry of Agriculture and Forests of Bhutan
MRDI	Mekong Research & Development Institute (CTU, Vietnam)
MSC	Most Significant Change technique
NARS	National Agricultural Research System
NTFP	Non-Timber Forest Product
NGO	Non-governmental organization
NNP	Nanthaburi National Park (Thailand)
NRM	Natural resource management
ODD	Overview - Design concepts – Details standard protocol for the description of ABMs
PN25	Project number 25 of CPWF (see at: http://www.cpwf25.sc.chula.ac.th)
PSU	Prince of Songkla University (Thailand)
RNR-RC	Renewable Natural Resource Research Center of MoAB (Bhutan)
RFD	Royal Forestry Department (Thailand)
RLR	Rainfed Lowland Rice
RPG	Role-Playing Game
RUB	Royal University of Bhutan (Bhutan)
TAO	Tambon (sub-district) Administrative Organization (Thailand)
UBU	Ubon Rajathanee University (Thailand)
UNDP	United Nations Development Program

RESEARCH HIGHLIGHTS

Water management problems in the Mekong basin and the Himalayan highlands tend to be complex and take place in rapidly changing and uncertain realities. A growing number of stakeholders are involved with own interest, strategies, water use practices, and perceptions of the problem at stake. Their points of view on water management are legitimate and need to be incorporated into collective decision-making processes through mediation and negotiation. A suitable approach to facilitate such a process needs to reconcile ecological and social dynamics, improve communication, collective learning, coordination mechanisms, and stakeholders' capacity for adaptive management and collective action. This is why PN25 was implemented to examine the following key questions: how to model different stakeholders' perceptions of a common water management problem? How to integrate indigenous & science-based knowledge to create a common representation of the system to be managed collectively? How to use models in multi-stakeholder decision-making processes to improve their capacity for adaptive management of water at the catchment scale?

A common Companion modeling (ComMod) collaborative modeling and simulation approach was adopted (see at: <http://www.commod.org/en>) and a methodological framework developed among PN25 partners and applied at nine different sites in three countries (Vietnam, Thailand and Bhutan) distributed in the main and contrasted agro-ecological zones and socio-cultural contexts of the basin to examine diverse water management problems leading to a variety of key outcomes: the coastal area of the Mekong delta in Southern Vietnam (water salinity management for rice and shrimp production), the drought and flood-prone rainfed lowland rice ecosystem of Northeast Thailand (interactions between land & water use in rice and labor migrations), the sloping and fragile uplands of upper northern Thailand (4 sites: upstream-downstream interactions and institutional coordination, irrigation water sharing among different types of plantation owners, headwater forest conservation and food production, headwater forest conservation and livestock production,), and the Himalayan highlands of Central West and Eastern Bhutan (3 sites: irrigation water sharing at rice transplanting among villages & institutional dynamics, water scarcity for domestic use, cropping and animal rearing, headwater conservation and management of grazing land). PN25 partnership combined regional universities implementing development-oriented research at the selected sites in Vietnam and Thailand, and the leading NRM research organization of the NARS in Bhutan. Training of local collaborators was emphasized at all PN25 sites with the aim of making them autonomous in the use of the ComMod approach and its specific tools in order to facilitate the future replication of this pioneer set of case studies.

ComMod is an interactive process facilitated by evolutionary models used as mediating tools to facilitate communication, support dialogue, shared learning, collective decision-making and the design of concrete action plans. Based on the definition of the water management problem to be examined, the modeling and simulation activities were driven by the interest of the end users and the focus evolved according to their evolving demands. Stakeholders (the researchers being one category among them) learned together by creating, modifying, observing and assessing simulations of scenarios identified collectively. Knowledge, perception, behavior, and practices evolved along the process and led to the negotiation of action plans and, in several cases, their implementation during the project thanks to better community mobilization.

In particular, ComMod use conceptual models, role-playing games (RPG), and agent-based models (ABM) and simulators in an iterative way, alternating field and laboratory activities in loops, to represent how competing water use processes are operating, and to search for acceptable solutions through better coordination and collective scenario assessment. RPG focusing on stakeholders' interest are taken seriously by the participants in field workshops and is a prove tool to communicate, enrich and validate the conceptual model associated with the issue to be examined. While the ABM tool is efficient to communicate the results of

long gaming sessions organized at the village community level to policy and decision-makers. The use of an ABM playing the RPG *in silico* is also a time and cost efficient way to simulate the scenarios proposed by the local participants by making use of the similarities and synergies between these key tools. ABMs, or hybrid simulators (in which several players make decisions in parallel with computer agents) were also found useful to out-scale the results of RPG-based workshops to larger groups.

The project demonstrated that the ComMod approach can be used to understand a complex water management system with local actors or to facilitate collective decision-making in multi-stakeholders platforms leading to coordinated collective action at the community level. The array of case studies showed that diverse outcomes emerge, at both the individual participant and collective level, depending on the specificities of the process dynamics. The main effects of ComMod activities recorded are improved communication, knowledge acquisition and exchange, changes in own and others perceptions, behavior, decision-making and practices, engagement and community mobilization, and creative design of local institutions.

PN25 led to the improvement of communication and trust among multiple stakeholders through collective learning facilitated by interactive simulations. In Lam Dome Yai watershed of Ubon Ratchathani province in Northeast Thailand, a computer simulator representing land and water use in rice farming & labor management dynamics integrates academic and indigenous knowledge and can be used to assess scenarios based on increased water or labor availability. In Tha Wang Pha District of Nan province, Northern Thailand, the ComMod activities led to improved communication and mutual understanding between foresters in charge of the conservation of headwaters and the villagers on gathering of non timber forest products by poor households. In the Sheytimi grasslands of Radi, Trashigang district, Eastern Bhutan, PN25 was able to establish a communication channel between the Meraks and Radips yak and cattle herders respectively to examine ways to use severely overgrazed natural pastures in order to decrease the risk of soil erosion and landslides affecting the rice terraces in the mid and lowlands of this watershed.

PN25 raised the capacity of local stakeholders and strengthened or created local institutions to tackle common NRM issues in diverse contexts. In Mae Hae, Chiang Mai Province, North Thailand, the networking of villages staggered in the catchment led to an agreement on a new regulation for irrigation water use. While at the nearby Mae Salaep catchment of Chiang Rai Province, the minority highland villagers designed an action plan for the establishment of new water storage and distribution infrastructure and were seeking funding from the local sub-district administration. In Lingmuteychu watershed of Punakha District in West central Bhutan, an initial ComMod process with two upstream villages in conflict over the sharing of irrigation water at rice transplanting was followed by another cycle of similar activities with the whole seven villages in this catchment leading to the creation of an operational watershed resource management committee that has been implementing the agreed upon action plan to develop water resources and reforest the sloping land. While in Kengkhar village of Mongar District in Eastern Bhutan where water scarcity is severe, the ComMod activities led to the coordinated use by the households from several hamlets of a network of seven interdependent water tanks built at different springs.

The implementation of Companion modeling approach in PN25 contributed to the mediation of water use conflicts through the design and use of families of models with stakeholders. In Bac Lieu Province of the Mekong delta, Vietnam, downstream shrimp producers reached a compromise with upstream rice growers on the timing of saline water intake at the sluice gate for shrimp farming. At Doi Tiew site of Nan province in Northern Thailand the mediation of the conflict between foresters and herders for the access to grazing land led to an agreement on a joint experiment to test new cattle rearing techniques on land provided by the forestry agency.

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The comparison of the ComMod processes implemented in three different countries demonstrated that this collaborative modeling approach leads to stronger effects and impact when a supporting community-based NRM policy is already in place. The case studies also showed that the management of social inequity, power relations & linkages with institutions at higher levels of organization are crucial, especially for up-scaling such participatory modeling and simulation processes.

All the project outputs are available on PN25 website at the following address:

<http://www.cpwf25.sc.chula.ac.th>

EXECUTIVE SUMMARY

Background, justification, and key questions

Water management problems in the Mekong basin and the Himalayan highlands tend to be complex and take place in rapidly changing and uncertain realities. A growing number of stakeholders are involved with own interest, strategies, water use practices, and perceptions of the problem at stake. Their points of view on water management are legitimate and need to be incorporated into collective decision-making processes through mediation and negotiation. But poor coordination among stakeholders leads to inefficient water use, economic and environmental damage, negative externalities, and social conflicts. In the current context of decentralization of the management of local renewable resources, there is a demand for innovative approaches, methods, and tools to improve the system adaptive capacity through better coordination and negotiation processes among an increasing number of stakeholders using common water resources.

Because more resilient water management systems require improvements in the interactions between ecological and social subsystems at the catchment scale, PN25 was conceived to design, test, evaluate, and provide training on innovative methodologies and tools enhancing stakeholders' collective learning capacity to facilitate better coordination among water users and collective action through community-based organization governing water resources. Communication platforms were set up at each key site to facilitate the effective participation of marginalized and often voiceless groups such as resource-poor households and women.

PN25 was implemented to answer the following key questions:

- How to model scientifically different stakeholders' perceptions of a common water management problem, and the way they influence individual and collective decision-making processes regarding water management?
- What rigorous process can we use to model a system of representations with the concerned stakeholders?
- How can we use it to improve coordination and facilitate negotiation among stakeholders to solve concrete water management problems?
- How far can we go in stimulating collective learning by integration empirical indigenous, technical, expert, and science-based knowledge into a common representation of the system to be managed collectively? And
- How to use models in multi-stakeholder decision-making processes to improve their capacity for adaptive management of water at the catchment scale and used to explore and assess possible future scenarios collectively?

The project adopted the Multi-Agent Systems (MAS) approach and Agent-Based Modelling (ABM) to represent linkages between biophysical and socioeconomic characteristics of a catchment system as well as the heterogeneous water users. PN25 general hypothesis stated that a MAS-based collaborative modelling and simulation approach could be used to stimulate dialogue, to elicit stakeholders' knowledge and perceptions of water dynamics, and to build shared representations of water management problems to be managed collectively. While ABMs co-constructed with the concerned stakeholders could be used to examine scenarios of resource sharing, and to facilitate negotiation and the emergence of coordination mechanisms among local water users.

Objectives

The project complementary specific objectives were threefold. They dealt with methodological development, capacity building, and the participatory construction of

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propositions for local and concrete adaptations to increase water productivity and improve its governance at the catchment scale:

- 1 To offer tools and a methodology for their use enhancing the capacity of expression of the different stakeholders' perceptions, to facilitate their collective assessment of the problems at stake, and to improve coordination among users through the collective identification and assessment of scenarios of change leading to agreed-upon action plans.
- 2 To train a group of scientists and development officers engaged in collaborative modelling and simulation processes on this methodology and its tools. They tested and adapted the method based on their interest and tailored its related tools at the key sites according to their evolving needs. A network of users is created and is linked to an international one.
- 3 To analyze concrete water and land management issues at the catchment level, and stakeholders' interactions that are specific to the respective water-related problems identified in each context. These participatory analyses lead to a collective assessment of potential changes to increase water productivity and its governance, as well as the design of suitable and feasible scenarios of (technological and organizational) adaptation to these changes. These scenarios are simulated and assessed with the stakeholders to examine the conditions allowing to create the desired situation.

Research Regions and Site Selection

The target catchments and watershed of this project were located in the Mekong Delta in Southern Vietnam (1 site), and at different elevations in the Mekong River Basin in Northeast (1 site) and Northern (4 sites) Thailand. Three additional sites located in West central (1 site) and Eastern (2 sites) Bhutan provided complementary situations at higher altitude. In these watersheds, diverse stakeholders with differing perceptions of water dynamics and its use have adopted various strategies and practices to cope with site specific water-related problems. Therefore, there is a need, to understand the factors framing and influencing these different stakeholders' perceptions, and how they may evolve to allow greater coordination and equitability in water use at the system level leading to increased water productivity and better governance of the resource.

These PN25 nine key sites were distributed in the main and contrasted agro-ecological zones and socio-cultural contexts of the Mekong basin to examine diverse water management problems as follows:

- Bac Lieu coastal province of the Mekong delta in Southern Vietnam: water salinity management in canals for rice and shrimp production.
- Lam Dome Yai watershed in Ubon Ratchathani province of lower Northeast Thailand: interactions between land & water use in rainfed lowland rice production and labor migrations.
- Nam Haen in Tha Wang Pha district of Nan province in Northern Thailand: competing claims for land use between headwater forest conservation and food production.
- Doi Tiew catchment in Tha Wang Pha district of Nan province in Northern Thailand: mediation of a land use conflict between foresters in charge of head watershed conservation and local Hmong herders.
- Mae Salaep catchment in Mae Fah Luang district of Chiang Rai Province in upper Northern Thailand: irrigation water sharing in the dry season among different types of plantation owners.
- Mae Hae watershed in Chiang Mai province of upper Northern Thailand: upstream-downstream interactions among irrigation water users & institutional coordination in a network of villages.

- Lingmutyechu watershed in Punakha district, West central Bhutan: irrigation water sharing at rice transplanting among seven villages & institutional dynamics.
- Kengkhar village in Mongar district, Eastern Bhutan: alleviation of water scarcity for domestic and other types of use and coordination among water users.
- The Sheytimi grasslands of Radi in Trashigang district, Eastern Bhutan: mediation of a pasture use conflict between two communities of yak and cattle itinerant and sedentary herders respectively to decrease the risk of soil erosion and landslides affecting the district rice terraces in the mid and lowlands of this watershed.

Approach, Methodology and Tools

Water users' interactions, among them and with their common environment and the source of this crucial resource, are crucial to take into account to increase the capacity of communities for adaptive management and the resilience of their social-ecological land & water systems. To deal with rapid change in resource and social dynamics it is essential to acquire an increased capacity for learning and adaptation by learning to live with uncertainty, integrating different types of knowledge, maintaining diversity and creating opportunities for self-organization. Recent advances in integrated and participatory modelling of land and resource use by multiple users allow the representation of multiple view points and the articulation of multiple levels between local individual behaviour of components and the global behaviour of the system subjected to emerging phenomena. To be useful, such integrated models should allow retrospective & prospective analyses of scenarios, be open and, most important, they must be understood and seen as relevant by the stakeholders. Therefore, they need to be constructed with and for them.

The construction of a shared representation of the interactions among stakeholders and with their complex socio-ecosystem is an important step toward improved integrated water resource management (IWRM). Innovative approaches and tools for improving communication, supporting collective learning, and facilitating negotiation and coordination mechanisms among stakeholders are needed to achieve such a goal. Among the family of collaborative modelling and simulations approaches, the Companion modeling (ComMod, see at: <http://www.commod.org/en>) approach and methodological framework was selected to be tested, adapted and transferred to the project partners.

ComMod is an interactive process facilitated by evolutionary models used as mediating tools to support dialogue, shared learning, to facilitate negotiation and collective decision-making to strengthen the adaptive management capacity of communities through integrative and inclusive collaborative modelling and simulation activities. The main principle of the ComMod approach is to co-construct simulators integrating various stakeholders' points of view with the end users and to use them to examine concrete common resource management problems with them. The ComMod approach can be used in two different contexts encountered at the project key sites:

- To understand the management of resources in a complex socio-ecosystem, but also
- To facilitate the collective management of these resources with concerned stakeholders by using participatory simulations within platforms for communication and collective learning.

It is a constructivist and trans-disciplinary modelling and simulation approach used:

- To understand the resource system to be managed by integrating knowledge across disciplines (especially ecology and social sciences) and from various sources (empirical, technical, scientific, etc.), and to produce new knowledge *via* in-depth and iterative interactions between researchers and stakeholders,
- To represent it by facilitating the collective co-construction of shared representations of common problems,
- To model it by implementing these representations into multi-agent simulators, either Role-Playing Games (RPG) or computer Agent-Based Models (ABM), sharing the same

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conceptual model and usually associated to build on their similarities and comparative advantages.

- To support dialogue, joint learning and negotiation by simulating different resource management scenarios selected by the stakeholders, and to assess them collectively by examining the uncertainties of the situation with all concerned parties in order to evaluate their impacts on the resource and its different types of users.

In ComMod processes, researchers are considered as a category of stakeholders among others. All of them learn together by creating, modifying, observing and assessing simulations. Knowledge, perception, behavior, and practices evolve along the successive cycles of the process.

Multi-agent systems (MAS) is the modelling approach used in ComMod to understand how different water (bio-physical, agricultural, social) processes in direct competition are coordinated (or not), and to mediate the collective search for acceptable solutions and improvements facilitated by exchanges on the effects of simulated scenarios on the different categories of stakeholders and the resource dynamics. ABMs are usually used in synergy with RPGs to allow the stakeholders' involvement in the co-construction of the simulator. The modeling and simulation activities are driven by end users interest. They are able to choose its focus and to influence the selection of its structure and rules while criticizing the researchers' representations of the collective problem under study. The collaborative modelling activities allow the participants to understand the computer simulator operations when this tool is used to run time and cost efficient simulations of scenarios selected by them. The RPGs and their associated ABMs are complementary modelling tools combined in iterative cycles of ComMod activities to improve mutual understanding and the stakeholders' capacity to collectively explore the uncertain future. At completion of a ComMod process, a family of models is available that can be used to recall the history of the collaborative modelling process: change in focus from one cycle to the next and related modifications of the simulators, evolution of the arena of stakeholders involved, etc. All the computer simulation toolkits developed at the project nine sites were implemented under the Common-pool resources and multi-agent systems (CORMAS) modeling and simulation platform ([http:// cormas.cirad.fr](http://cormas.cirad.fr)).

Much attention is given to the quality of the collaborative process: degree of participation of the concerned parties, management of asymmetries of information and power relations, etc. The stakeholders learn collectively by creating, modifying, and observing simulations used as a mediating tool. They also modify their representations of the problem at stake or create new ones. ComMod processes designed to support collective decision making can lead to the definition of agreed upon action plans having a good chance of being implemented thanks to stakeholders' engagement and better community mobilization. Focused group debates, individual interviews of participants, and external evaluations were used to assess the diverse effects and impacts of the ComMod processes carried out at the project key sites.

Research findings

Methodological development in collaborative modeling and simulation

The implementation of ComMod processes at nine sites in three countries confirmed the suitability of this methodology for enhancing the capacity of expression of the different stakeholders' perceptions on diverse water issues, to facilitate their collective assessment of these problems, and to improve coordination among users through the collective identification and assessment of scenarios of change among stakeholders. At several sites, the project activities led to agreed-upon action plans on how to better share water resources and to their implementation during the duration of the project.

The comparative analysis of the ComMod processes shows the adaptive and flexible characteristic of the ComMod collaborative modelling and simulation activities, either when the objective is to better understand a complex collective water management system by building a shared representation of it (3 sites where the model is the key output of the process), or to facilitate collective decision-making by the concerned stakeholders (6 other sites where the model supports the negotiation). The development of the methodology also clarified what is meant by “participatory (collaborative) modelling” or/and “simulation” by distinguishing between participation in the design, the co-construction of the model and participation in the use of the model. These different situations occurred at different PN25 sites with specific dynamics of participation and of the context along the process driving the evolution of the question to be examined and the related changes made in the simulation tools to be able to answer new stakeholders’ demands. From one ComMod cycle to the next, such processes produce families of “disposable” models used once and then discarded because they are not relevant anymore to answer the actors’ requests.

Modelling of biophysical processes in the ComMod models developed at project sites

With no exception, the representations of the bio-physical processes in the ComMod models developed, at each of the six sites where such a module was needed to represent the issue at stake, were simple ones. When a more sophisticated water models was available beforehand the early phases of the ComMod processes, it had to be simplified later on because the stakeholders were more interested to focus on other key aspects, especially the social ones.

Diversity of effects and impacts of ComMod processes for water management

The comparative analysis of these ComMod processes also illustrates the diversity of effects and impacts generated by such activities at both the individual and collective levels: enhanced communication, knowledge acquisition and sharing, change in own and others perceptions, behaviour, decision-making and practices, community mobilization, creative institutional design, etc. It is also demonstrating the importance of monitoring the evolution of the context along the participatory modelling and simulation process to be able to fully understand the change of direction decided by the local actors.

Capacity building, contingent empowerment and trust building

The comparative analysis of PN25 ComMod case studies on water management at the catchment scale also looked at participatory modelling and simulation as a way to empower people depending on their degree and timing of involvement in the process, on the composition of the arena of participants, the evolution of the context, etc. This is because the project team assumed that building up trust and legitimacy along the process can boost the chance to achieve the desire outcome of the participatory modelling process. But different empowerment and trust building paths and drivers were found between case studies, depending on the context, history of the issue, and methodological choices in particular.

Catchment governance structures and institutions

At each of the project key sites, concrete water and land management issues were examined at the catchment level. Stakeholders’ interactions specific to the respective water-related problems were identified, contextualized and analyzed before to be modelled in the simulators. Following their social validation, these simulation tools were used for the collective assessment of potential changes to improve water management and its governance based on the results of simulations of scenarios of (technological and organizational) change identified by the local stakeholders. At several sites in Vietnam and Northern Thailand, the process led to agreements on new water management rules

among stakeholders. While at the Lingmutyechu and Kengkhar sites of Bhutan, the ComMod activities facilitated the design and establishment of new local institutions (locally called “Watershed management committee”). Two supporting characteristics of the context in this country could explain why this was possible: the availability of a national policy favouring Community-based NRM and the joint implementation of the ComMod processes with the local agricultural extension system that provided active site facilitator permanently based in those catchments.

Outcomes and Impacts

The ComMod processes implemented at nine diverse sites in three countries and in different agro-ecological zones and socio-cultural contexts dealing with different water management problems led to a variety of key outcomes depending on the process dynamics. We grouped them in the following three categories:

1. PN25 raised the capacity of local stakeholders and strengthened local institutions to tackle common NRM issues in diverse contexts,
2. PN25 led to the improvement of communication and trust among multiple stakeholders through collective learning facilitated by interactive simulations,
3. The implementation of Companion modeling processes contributed to the mediation of water use conflicts through the design and use of families of models with stakeholders.

Practically, in Bac Lieu province of the Mekong delta, Vietnam, the process led to the adjustment of water quality requirements in the canals allowing farmers to grow more rice and include other components in their farming systems rather than only shrimp monoculture, to minimize the economic risk. The local impact pathway let us think that similar adjustment of water requirements could occur in other neighboring provinces, facing the same problem of coordination of the management of the salinity control system leading to more land use change by farmers.

In the rainfed lowland rice (RLR) ecosystem of Ubon Ratchathani, the co-design of a simulator representing the interactions between water, RLR production and labor migrations improved very significantly the participating farmers’ communication skills and led to new demands. They are able to present their ABM simulator to M.Sc. students and faculty at the local University and this illustrates a major change in the relationships between farmers and researchers due to ComMod activities. They now request a new project to look at the diversification out of rice and the product marketing issues. In the upland areas of Northern Thailand, improved cropping patterns for more adaptive farm management and resource-sharing were observed at the Maehae site making local farms less vulnerable to market price and rainfall fluctuations. The village committee leaders need to keep enforcing the implementation of the agree-upon resource use practices and to institutionalize the organization of interactive workshops to foster collective thinking and exchange of practices. While at the nearby Mae Salaep site, the village leaders are eager to look for an alternative donor following the rejection by the sub-district administration of the water storage and distribution project designed by the villagers during the process because of a conflict of interest. Also in the Northern Thailand highlands, an agreement between villagers and foresters for the joint management of resources along the local forest – farm land interface was formally signed by all parties involved in the Nam Haen catchment of Nan province, and this could secure a continuous access to NTFPs by the most vulnerable farming households based on a new set of agreed upon rules. At the adjacent Doi Tiew site, the adoption of artificial pastures by the local herders who wish to continue to rear cattle in this catchment could lessen the pressure on natural grasslands and facilitate the reforestation of the headwater areas. More households would be able to continue to farm in the area and would be less vulnerable to market price fluctuations thanks to combinations of crop and animal productions.

In Lingmutyechu catchment of Western Central Bhutan, water sharing and management through the establishment of a local management committee that promotes equitable access to water was achieved. But the initial success re-ignited an old conflict in downstream communities to be resolved by the Management committee through consultation. While at the Kengkhar site of Eastern Bhutan, sharing water by a network of tanks reduces time and energy for water collection, particularly by women and children, and assures clean water for longer period. The impact pathway benefits from the engagement of school and health offices in supporting further improvement of the water supply system through roof water harvesting. This was not expected initially as they do not control springs and have independent water supply systems. It will now be easier to disseminate this experience to other areas as this case study is considered as a pilot one at the national level. In the same region, fencing and rotational grazing were identified by the local stakeholders to better manage the Sheytimi grazing lands at Radi site, while a major plantation project is being finalized to rehabilitate the already degraded parts of these over-grazed highlands. Again, the reforestation of the upper catchment was not expected as it was not included in the question examined in the ComMod process. But it would keep the two communities of herders in conflict and their respective grass lands separated by a green belt, while they will collectively benefit from the plantation.

PN25 had a strong training component made of complementary activities. Six site coordinators (3 Thais and one Bhutanese, French and Vietnamese each) undertook doctoral studies during the project, two of them under a joint-degree program between Paris Ouest Nanterre La Défense University, France (Human, economic and regional geography doctoral programme) and Chulalongkorn University in Bangkok, Thailand (Agro-technology PhD program). Three of them graduated at Paris Ouest University in France with the unanimous congratulations of the jury and another one also obtained the top mark at Lyon University, France. A Thai master student supported by the project graduated in "Integrated farming" at the Faculty of Agriculture, Ubon Rajathanee University, Thailand in February 2009 and a Bhutanese collaborator was granted a diploma degree in "integrated watershed management" from Kasetsart University in Bangkok in May 2009. We observed that in all cases, the doctoral research implemented by the students required more time than planned due to the difficulty of the subject (requiring system thinking, a critical assessment of own work, an array of skills from group facilitation to the command of a computer modelling and simulation platform). But at the end of the project, all the Thai and Vietnamese PhD students have graduated and are back in their respective Faculties and Universities where they use their new knowledge in teaching appropriate master programmes.

A small regional network of users was created during the project and is linked to two international ones: the ComMod network gathering people interested by this approach, and the CORMAS list of users of this MAS simulation platform. The innovative methodology and its key tools is currently being transferred to more interested people through local institutions of higher education where several of PN25 site coordinators are teaching. At the end of the project, a regional training course on the approach was designed and held at Chulalongkorn University in Bangkok during which the project PhD candidates were able to make presentations of their results (see below the list of PN25 training materials).

International Public goods

Apart from the new knowledge generated through the research at the 9 different sites, the project produced two important international public goods: a refined and field-tested version of the ComMod approach for collective management of water at the catchment scale (see at: <http://www.commod.org/en>), and a set of freely available modelling and simulation tools that could be fine tuned to examine similar water management issues at other sites. All of them were implemented under the CORMAS simulation platform (which is available at <http://cormas.cirad.fr/indexeng.htm> where one can find tutorials for self-training, descriptions of the ABMs developed according to the Overview - Design

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concepts – Details –ODD- standard protocol for documenting such models and their code). The descriptions of many RPGs produced by PN25 are available as powerpoint presentations. A template of the logbook designed for monitoring ComMod processes is also available, as well as examples from several sites. Similar ComMod processes have also been applied at some 40 different sites in African, Asian, European and Pacific Ocean countries. 27 of these case studies (including 5 from PN25) were assessed under a special project during 2007-2009 and the results were published to further disseminate the lessons learnt from these early experiments with ComMod. The PN25 website (see at <http://www.cpwf25.sc.chula.ac.th>) is another key tool used to make PN25 outputs (news, training materials, library of models, case studies, publications, video clips, photos, etc.) available (including in national languages) to interested people.

Partnerships achievements and networking

Close relationships among PN25 partners were developed thanks to five technical workshops associated with cross site visits, joint organization of training courses in Bhutan and Thailand, the preparation of conference papers and journal articles, and formal & informal joint academic activities among PN25 PhD students. New linkages between IWMI – ARIs – NARS of the three countries involved were established and broader networking achieved through PN25 participation in the first and second International Forum on Water and Food (IFWF) in 2006 and 2008 respectively. The continuous improvement of the PN25 website also played a role in networking and the integration of the project in the global ComMod network of practitioners. In 2009, the site coordinators in Thailand organized themselves to help a new node of the Thai network to get started at the Faculty of Natural Resources of Prince of Songkla University (FNR-PSU), while trainees from 12 different countries attended the final training event in May 2009. Some links with other CPWF projects in the Mekong basin led to joint publications, and the close association of PN25 with the Echel Eau Project played a crucial role in training activities, particularly in the last year of the project. PN25 also provided opportunities to access funding from UNDP & DANIDA for farmers groups at two sites in Bhutan.

Recommendations

In the field of research, this project showed that working as a network, sharing a common methodology, tools, and experiences grounded in local organizations has been very productive. It also underlines the need to adapt participatory modelling processes to the specificities of local situations and to care for people who are interested for better impact. Good participatory modelling research requires a flexible time line, and further work is still needed to make the computer tools to build models more user-friendly. Now that a small regional network of CORMAS users has been established, it is also proposed that members with good programming skills could support other members in developing their computer simulation tools.

For extension, PN25 showed the importance of learning by doing training activities for extension agents who are very important partners in such processes. Specific efforts are needed to make them (and researchers) true facilitators of such processes and, because of their intensive interactions with local actors, it is essential to involve them in on-site monitoring and evaluation of participatory modelling processes.

Regarding policy, more time should have been allocated at the beginning the project to sensitize administrators and policy makers to better involve them in participatory processes at a later stage, taking into account the fact that they move frequently from a position to another one making difficult the assessment of the right time to engage them for lasting impact. It is also essential to take into account the way dialogue and action with policy makers works, often not according to gradual steps from a given organization level to the next one. This collaborative modeling approach works better when a supporting community-based NRM policy is in place.

About institutions, PN25 achievements show the importance of institutional support for lasting outcomes & impact of such collaborative modelling processes. Very tangible impact was observed where a supporting policy and institutional framework was available allowing the exciting creative design of local institutions for collective management of water. But in any context, the management of social inequity, power relations & linkages with institutions at higher levels of organization are crucial for the success of such processes, especially when up-scaling them.

Regarding CPWF, the PN25 author team thanks the managing team for the flexibility in timing of implementation granted as it is much needed in this area of research. The two IFWF forums were also highlights along the project life span.

Publications

So far, 16 peer-reviewed journal articles, 7 book chapters, 38 conference papers and 9 posters have been published by this project. More journal articles are still under preparation following the recent termination of doctoral studies by several site coordinators. All PN25 publications and training materials on the ComMod approach and its specific tools are deposited at <http://www.cpwf25.sc.chula.ac.th> .

INTRODUCTION

Water management problems at the catchment scale in the Mekong basin and the Himalayan highlands tend to be complex and take place in rapidly changing and uncertain realities. Complexity finds its origin in interactions between bio-physical, environmental and economic processes affecting water availability and management at the household and catchment levels, social interactions among (culturally, socially and economically) heterogeneous stakeholders having often competing interests and engaged in power relations, and a constantly changing and uncertain broader context, which includes policy change (such as decentralization of natural resource management - NRM), and evolution of economic conditions (such as price fluctuations). A growing number of more and more diverse stakeholders are involved in such complex water management issues, having their own key interest, strategies, water use practices, perceptions of the problem at stake, and of the other concerned actors they know. Their points of view on water management are legitimate and need to be incorporated into collective decision-making processes through mediation and negotiation. But poor coordination among stakeholders leads to inefficient water use, economic and environmental damage, negative externalities, and social conflicts. In the current context of decentralization of the management of local renewable resources, there is a demand for innovative approaches to facilitate the engagement of the concerned stakeholders into the search for acceptable improvement of current (often conflicting) situations. Methods and tools to improve the system adaptive capacity through better coordination and negotiation processes among an increasing number of stakeholders using common water resources have to be designed, field tested and their effects and impact assessed with the users.

Background, justification, and key questions

Because more resilient water management systems require improvements in the interactions between ecological and social subsystems at the catchment scale, PN25 was conceived to design, test, evaluate, and provide training on innovative methodologies and tools enhancing stakeholders' collective learning capacity to facilitate better coordination among water users and the planning and implementation of collective actions through community-based organization governing water resources. The research team has chosen to set up communication platforms at each of the project key site to facilitate the effective participation of marginal and often voiceless social groups, such as resource-poor households and women, into processes of exchange of information, perceptions, and coordination among actors to support more negotiated and equitable collective decision-making patterns. Due to the complexity and unpredictability of the context of most of the current water management problems, the use of open and collaborative modeling and simulation approaches seems appropriate. This was confirmed by the preliminary results obtained under previous projects implemented in Southeast Asia between 2001 and 2005 which served as the foundations of PN25 (see in particular Bousquet, Trébuil and Hardy 2005, and the website of the Ecole ComMod project funded by the Asia IT&C program of the European Union at <http://www.ecole-commod.sc.chula.ac.th>).

PN25 was designed to address several key aspects of the CPWF vision and strategy presented in "The Vientiane Statement" released at the end of the First International Forum on Water and Food (IFWF) in November 2006 (CGIAR-CPWF 2006) such as the need to involve local stakeholders in water management decision-making, to support multiple-use water systems, to improve communication and collaboration among water users as well as water use governance at all scales, to introduce policies and develop institutions that encourage equitable and efficient water use in ways that reduce poverty and improve food security, etc. This was a call for action in favour of more research on risk management for vulnerable farms and communities, and on ways to manage conflicts among alternative water uses and users along with decision-support systems and scenario analysis to backstop dialogue among stakeholders. The statement also call for greater investment in

capacity-building in multidisciplinary and integrative approaches for researchers, development workers, and water management stakeholders, and for policies that establish regulatory frameworks that recognize multiple uses and empower local and indigenous water management systems.

Based on such background, PN25 was conceived to answer the following key questions:

- How to model scientifically different stakeholders' perceptions of a common water management problem, and the way they influence individual and collective decision-making processes regarding water management?
- What rigorous process can we use to model a system of representations with the concerned stakeholders?
- How can we use it to improve coordination and facilitate negotiation among stakeholders to solve concrete water management problems?
- How far can we go in stimulating collective learning by integration empirical indigenous, technical, expert, and science-based knowledge into a common representation of the system to be managed collectively? And
- How to use models in multi-stakeholder decision-making processes to improve their capacity for adaptive management of water at the catchment scale and used to explore and assess possible future scenarios collectively?

The project adopted the Multi-Agent Systems (MAS) approach and Agent-Based Modelling (ABM) to represent linkages between biophysical and socioeconomic characteristics of a catchment system as well as the heterogeneous water users (Figure 1-1 & Bousquet, Trébuil & Hardy 2005).

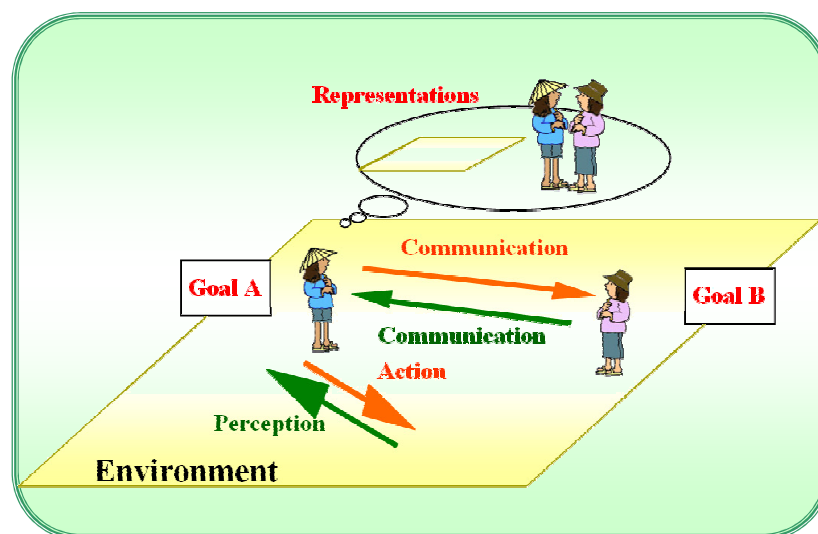


Figure 1.1: Schematic representation of a multi-agent system (adapted from Ferber 1999).

PN25 general hypothesis stated that a MAS-based collaborative modelling and simulation approach could be used to stimulate dialogue, to elicit stakeholders' knowledge and perceptions of water dynamics, and to build shared representations of water management problems to be managed collectively. While ABMs co-constructed with the concerned stakeholders could be used to collectively examine scenarios of resource sharing as a way to facilitate negotiation and the emergence of better coordination mechanisms among diverse local water uses and users.

Objectives

The project complementary specific objectives were threefold and dealt with methodological development, capacity-building, and the participatory construction of propositions for local and concrete adaptations to increase water productivity and improve its governance at the catchment scale:

1. To offer tools and a methodology for their use enhancing the capacity of expression of the different stakeholders' perceptions, to facilitate their collective assessment of the problems at stake, and to improve coordination among users through the collective identification and assessment of scenarios of change leading to agreed-upon action plans.
2. To train a group of scientists and development officers engaged in collaborative modelling and simulation processes on this methodology and its tools. They tested and adapted the method based on their interest and tailored its related tools at the key sites according to their evolving needs. A network of users is created and is linked to an international one.
3. To analyze concrete water and land management issues at the catchment level, and stakeholders' interactions that are specific to the respective water-related problems identified in each context. These participatory analyses lead to a collective assessment of potential changes to increase water productivity and its governance, as well as the design of suitable and feasible scenarios of (technological and organizational) adaptation to these changes. These scenarios are to be simulated and assessed with the stakeholders as a way to support the identification of the necessary conditions permitting to reach the desired situation.

Research Regions and Site Selection

PN25 worked at key sites located in the Mekong (6 sites) and Bhramaputra (3 sites) basins (Figure 1.2).

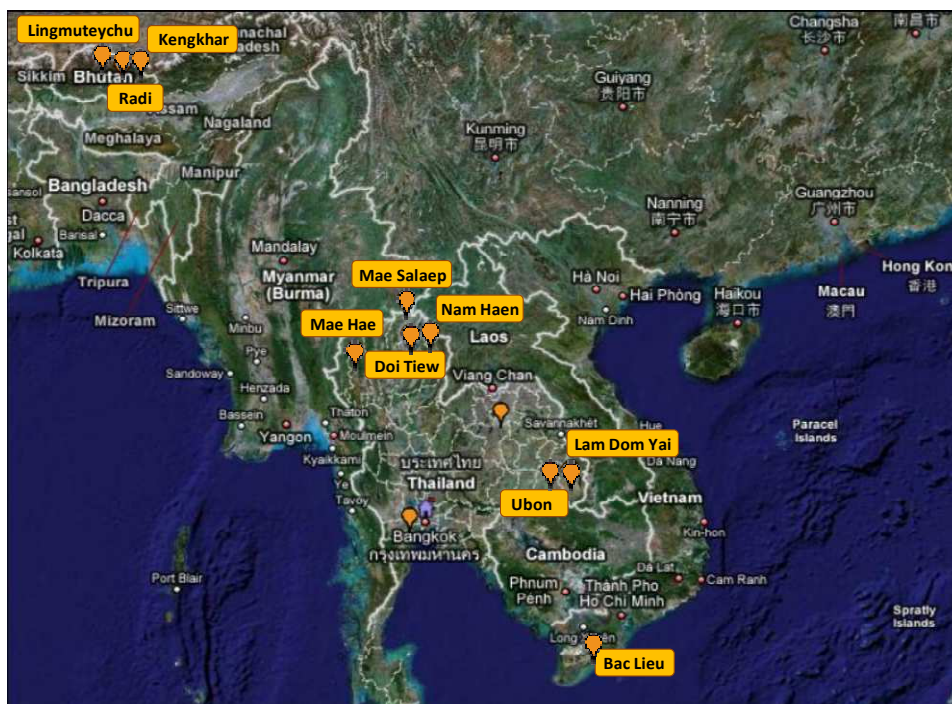


Figure 1.2: Location of PN25 nine key sites in the Mekong and Bhramaputra basins.

In the Mekong basin, the target catchments and watershed were located in the coastal zone of the delta in Southern Vietnam (1 site), and at different elevations along the Mekong River in Northeast (1 site) and Northern (4 sites) Thailand. Three additional sites located in West central (1 site) and Eastern (2 sites) Bhutan provided complementary situations at higher altitude. In these catchments, diverse stakeholders with differing perceptions of water dynamics and its use have adopted various strategies and practices to cope with site specific water-related problems. To be able to examine them, there is a need, to understand the factors framing and influencing these different stakeholders' perceptions and how they may evolve to allow greater coordination and equitability in water use at the system level leading to increased water productivity and better governance of the resource.

These PN25 nine key sites were distributed in the contrasted agro-ecological zones and socio-cultural contexts to test and compare the use and effects of a similar methodological framework and related tools on diverse water management problems nested in these different contexts. Detailed information on the characterization of these sites is provided below in Tables 1.1 and 1.2.

At each of the project key sites, the water problems to be examined were as follows:

- Bac Lieu coastal province of the Mekong delta in Southern Vietnam: water salinity management in canals for rice and shrimp productions having different water quality requirements. Research team leaders: Le Canh Dung, Chu Thai Hoanh & Christophe Le Page.
- Lam Dome Yai watershed in Ubon Ratchathani province of lower Northeast Thailand: interactions between land & water use in rainfed lowland rice production and labor migrations in the context of improving water availability. Research team leaders: Warong Naivinit, Manitchara Thongnoi & Christophe Le Page.
- Nam Haen in Tha Wang Pha district of Nan province in Northern Thailand: competing claims for land use between headwater forest conservation about a major reservoir and local food production. Research team leaders: Pongchai Dumrongrojwattana, Cécile Barnaud & Christophe Le Page.
- Doi Tiew catchment in Tha Wang Pha district of Nan province in Northern Thailand: mediation of a land use conflict between foresters in charge of head watershed conservation above a major reservoir and local Hmong herders rearing cattle on natural grasslands. Research team leaders: Pongchai Dumrongrojwattana & Christophe Le Page.
- Mae Salaep catchment in Mae Fah Luang district of Chiang Rai Province in upper Northern Thailand: irrigation water sharing at critical stage in the dry season among different types of plantation owners producing litchi and tea. Research team leaders: Cécile Barnaud, Guy Trébuil & François Bousquet.
- Mae Hae watershed in Chiang Mai province of upper Northern Thailand: upstream-downstream interactions among irrigation water users & institutional coordination in a network of villages. Research team leaders: Panomsak Promburom, Benchaphun Ekasingh & François Bousquet.
- Lingmuteychu watershed in Punakha district, West central Bhutan: irrigation water sharing at rice transplanting among seven villages & institutional dynamics for the local management of renewable resources. Research team leaders: Tayan Raj Gurung, Gyenbo Dorji, Aita Kumar Bhujel & François Bousquet.
- Kengkhar village in Mongar district, Eastern Bhutan: alleviation of water scarcity for domestic and other types of use and coordination mechanisms among water users. Research team leaders: Tayan Raj Gurung, Chokey Nima & Christophe Le Page.

Table 2.1: Site characterization, specific issues & diversity of stakeholders in three PN25 sites in Bhutan and one in Vietnam.

Topics/Sites	Lingmuteychu,	Bhutan Kengkhar	Radi	Vietnam Bac Lieu
Problem	Irrigation water sharing for rice cultivation	Scarcity of water for all purpose	Conflict among herders on pasture land and grazing	Conflict of water demand for rice and shrimp
Scale of the problem	7 villages	Almost the whole block (maximum to 52 household)	2 herder community, approximately 2000 acre pastures	2 villages (down and up stream)
Age and evolution of the problem	Since the settlement and increasing conflict	Ever since the population started to increase and natural forest declined	Since 1980	Since increasing shrimp monoculture in downstream area
Severity of the problem	High for 2 villages and Medium among 7 village	Severe in 7 communities, 4 month severe scarcity period	Very high social tension and environmental degradation	Low/medium (not burning)
Researchers-stakeholders linkage (includes past research at site)	Since 1987 onfarm research site, site for CBNRM	Database on land use pattern., catchments protection, roof water harvesting	Diagnostic study in 1997, Implementation of watershed management in 2003	Since 2002 when dividing different subzones in the province
Origin of demand and legitimacy.	Down stream communities. Highly legitimate.	Highly legitimate as issues raised in development discussion	Conflict stakes, severe environmental problem, legitimate,	Researchers' legitimacy thanks to previous research & projects
Opportunities & incentives to act	Increased access to irrigation water lead to increase rice production,	Access to clean drinking water and networking, saves time for other activities.	Grazing land management for higher livelihood for both communities, solution to land degradation.	Increased cooperation among stakeholders for irrigation serving for rice and shrimp

Table 1.2: Site characterization, specific issues & diversity of stakeholders of five sites in Thailand.

Topics/Sites	Lam Dome Yai	Mae Salaep	Nam Haen	Doi Tiew	Maehae
Problem	Water & labor management in rainfed lowland rice.	Irrigation water sharing in cash crop plantations	Forest conservation in upper catchment	Forest conservation and extensive cattle raising in highland	Forest encroachment, Shortage and unequal access of water
Scale of the problem	Mak Mai village (11 households)	1 Akha village (48HH)	2 Mien villages	1 village, 1 headwater management unit, 1 national park	14 Villages
Age and evolution of the problem	Existed there	Recent / rising due to increased cash cropping	Recent / establishment of new national park	Since 1990 and the establishment of headwater management unit	Since forest law (1950s), and recent drought years
Severity of the problem	Low currently, but important in the near future	Low/medium (not burning)	Severe for small farms	High for herders raising cattle, some herders decide to stop cattle raising	High (broken pipes), medium (conflict between ethnic groups),
Researchers-stakeholders linkage (includes past research)	Several years of research at site on other topics in the 90s	Several years of on-farm research on erosion control	No previous collaboration	Collaboration initiated following Nam Haen ComMod process	In 2001 sustainability assessment of land-forest resource
Origin of demand and legitimacy.	Low legitimacy, researcher driven research	Villagers after previous ComMod activities; good legitimacy	Researcher to local devpt. agency & village leaders; low legitimacy	National park requested research team to apply the same method & tools on this new topic	Researcher & watershed management unit, local development agency and communities
Opportunities & incentives to act	Planned investments in irrigation infrastructures at site raises the importance of this issue	Decentralization policy & allocation of financial resources at sub-district (TAO) level	Creation of new national park: redefinition of rules for access to forest products	Creation of a new national park: redefinition of rules for access to grazing land	Emerging common regulation to equitable water sharing and limit land utilization in headwater area.

- The Sheytimi grasslands of Radi in Trashigang district, Eastern Bhutan: mediation of a natural pasture use conflict between two communities of yak and cattle herders, itinerant Meraks and sedentary Radips respectively, to decrease the risk of soil erosion and landslides affecting the rice terraces in the mid and lowlands of this watershed. Research team leaders: Lhab Dorji, Tayan Raj Gurung & Christophe Le Page.

Approach, Methodology and Tools

Water users' interactions, among them and with their common environment and the source of this crucial resource, are crucial to take into account to increase the capacity of communities for adaptive management and the resilience of their social-ecological land & water systems. To deal with rapid change in resource and social dynamics it is essential to acquire an increased capacity for learning and adaptation by learning to live with uncertainty, integrating different types of knowledge, maintaining diversity and creating opportunities for self-organization. Recent advances in integrated and participatory modelling of land and resource use by multiple users allow the representation of multiple view points and the articulation of multiple levels between local individual behaviour of components and the global behaviour of the system subjected to emerging phenomena. To be useful, such integrated models should allow retrospective & prospective analyses of scenarios, be open and, most important, they must be understood and seen as relevant by the stakeholders. Therefore, they need to be constructed with and for them (Voinov and Bousquet 2010).

The construction of a shared representation of the interactions among stakeholders and with their complex socio-ecosystem is an important step toward improved integrated water resource management (IWRM). Innovative approaches and tools for improving communication, supporting collective learning, and facilitating negotiation and coordination mechanisms among stakeholders are needed to achieve such a goal. Among the family of collaborative modelling and simulations approaches and because one of its goal is the construction of such shared representation of the interactions between ecological and social dynamics, the Companion modeling (ComMod, see at: <http://www.commod.org/en>) approach and methodological framework was selected to be tested, adapted and transferred to the project partners (Figure 1.3).

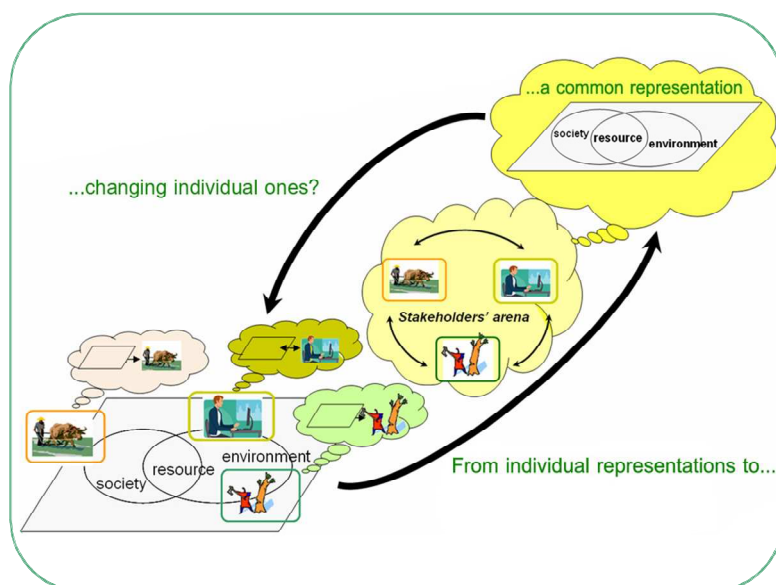


Figure 1.3: The co-construction of a shared representation of the water management system in companion modelling.

ComMod is an interactive process facilitated by evolutionary models used as mediating tools to support dialogue, shared learning, to facilitate negotiation and collective decision-making to strengthen the adaptive management capacity of communities through integrative and inclusive collaborative modelling and simulation activities (Etienne 2010). The main methodological principle of the ComMod approach is to co-construct simulators integrating various stakeholders' points of view with the end users and to use them to examine concrete common resource management problems with local actors (Bousquet, Trébuil and Hardy 2005; Bousquet *et al.* 2007, Ruankaew *et al.* 2010).

The ComMod approach is used in two different contexts encountered at the key sites:

- To understand the management of resources in a complex socio-ecosystem: this was the main goal of the ComMod process implemented at the Lam Dome Yai watershed in lower Northeast Thailand and was a necessary intermediary goal at all the other sites.
- To facilitate the collective management of these resources with concerned stakeholders by using participatory simulations within platforms for communication and collective learning: this goal was more or less achieved at these other eight sites.

ComMod is a constructivist, trans-disciplinary, iterative and evolving modelling and simulation approach (Figure 1.4) used:

- To understand the resource system to be managed by integrating knowledge across disciplines (especially ecology and social sciences) and from various sources (empirical, technical, scientific, etc.), and to produce new knowledge *via* in-depth and iterative interactions between researchers and stakeholders,
- To represent it by facilitating the collective co-construction of shared representations of common problems,
- To model it by implementing these representations into multi-agent simulators, either Role-Playing Games (RPG) or computer Agent-Based Models (ABM), sharing the same conceptual model and usually associated to build on their similarities and comparative advantages.
- To support dialogue, joint learning and negotiation by simulating different resource management scenarios selected by the stakeholders, and to assess them collectively by examining the uncertainties of the situation with all concerned parties in order to evaluate their impacts on the resource and its different types of users.

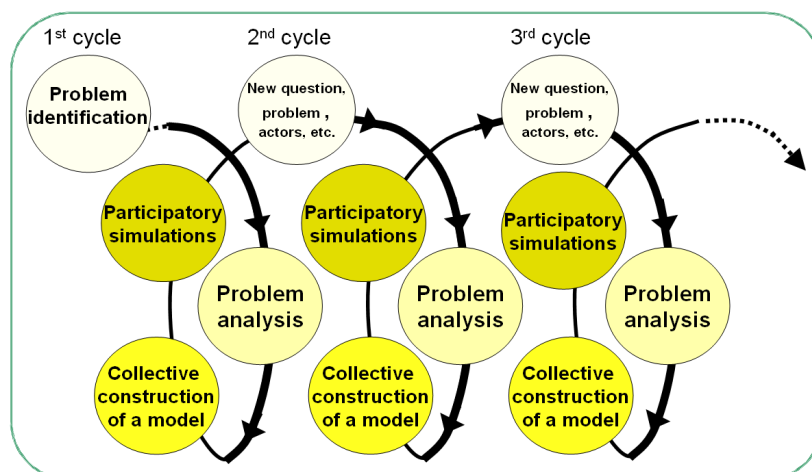


Figure 1.4: Schematic representation of a companion modelling iterative and evolving process of renewable resource management.

In ComMod processes, researchers adopt an original scientific posture because, far from being neutral agents, they see themselves as a category of stakeholders among others, bringing a specific point of view on the issue at stake into the collaborative process. Along this process, all stakeholders involved learn together by creating, modifying, observing and assessing simulations. Communication circles, knowledge exchange, perception sharing, behavior, decision-making and practice change evolve along the successive cycles of the process (Figure 1.4).

Because of its openness and flexibility, the Multi-Agent Systems (MAS) modelling approach is used in ComMod to understand how different water (bio-physical, agricultural, social) processes in direct competition are coordinated (or not), and to mediate the collective search for acceptable solutions and improvements facilitated by exchanges on the effects of simulated scenarios on the different categories of stakeholders and the resource dynamics. ABMs are usually used in synergy with RPGs to allow the stakeholders' involvement in the co-construction of the simulator (Figure 1.5). Both tools share the same conceptual model and their combination is very flexible: sometimes the RPG is used first (this was the far most frequent case at PN25 key sites), while in other cases the RPG is used to introduce a pre-existing computer ABM to the stakeholders.

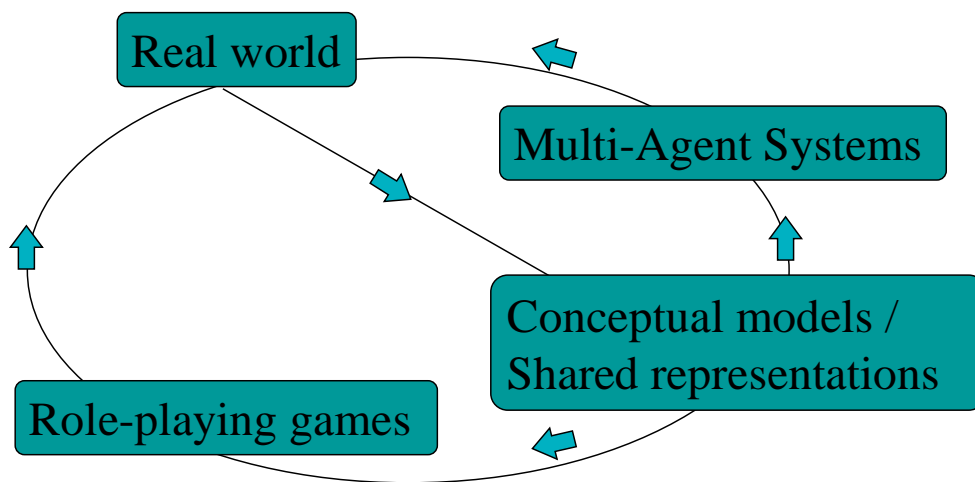


Figure 1.5: The flexible linkages between conceptual model, role-playing game and computer agent-based model in companion modelling.

In ComMod, the focus of the modeling and simulation activities is driven by the end users' interest, and this central interest usually evolve with time and as an effect of the previous activities. Therefore, in each of the process successive cycle, the stakeholders are able to choose its focus and to influence the selection of the structure and rules of the main simulation tool used (either a RPG, and ABM or an hybrid one), and to criticize the researchers' representations of the collective problem under study. The collaborative modelling activities centred on the use of successive versions of RPGs allow the participants to understand the computer simulator operations when this tool is used at a later stage to run time and cost efficient simulations of scenarios selected by them. Therefore RPGs and their associated ABMs are complementary modelling tools combined in iterative cycles of ComMod activities to improve mutual understanding and the stakeholders' capacity to collectively explore the uncertain future. At completion of a ComMod process, a family of models is available that can be used to recall the whole history of the collaborative modelling process with its change of focus from one cycle to the next, the related modifications of the simulators made, the evolution of the arena of stakeholders involved in successive cycles, etc.

All the computer simulation toolkits developed at the nine project sites were implemented under the Common-pool resources and multi-agent systems (CORMAS) modeling and simulation platform which is freely available at <http://cormas.cirad.fr>. The main interface of CORMAS platform, a simulation tool specifically designed to model interactions between ecological and social dynamics in renewable resource management, is shown in Figure 1.6.

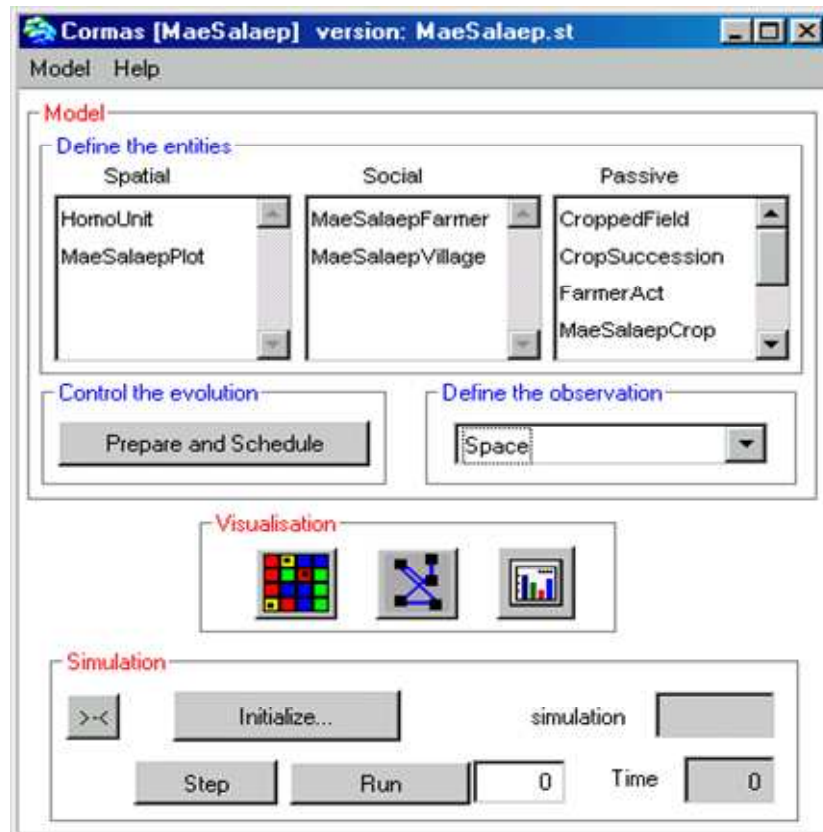


Figure 1.6: The main interface of the Common-pool resources and multi-agent systems simulation platform used to implement all the project agent-based models.

When implementing a ComMod case study, much attention is given to the quality of the collaborative process. Important aspects to be monitored are the degree of participation of the concerned parties (attempts are made to provide similar amounts of time to all parties involved to express their views), the management of asymmetries of information (with sometimes specific activities to support the disadvantaged participants) and power relations (with powerful stakeholders being included in the process in the second or third cycles at the request of the weaker ones only), etc. The stakeholders learn collectively by creating, modifying, and observing simulations used as a communication enhancing and mediating tool. They also modify their representations of the problem at stake or create new ones.

ComMod processes designed to support collective decision-making can lead to the definition of agreed upon action plans. It is assumed that they have a higher chance of being implemented thanks to the stakeholders' engagement and the better community mobilization obtained at the end of such a process. Focused group debates, individual interviews of participants, and external evaluations were used to assess the diverse effects and impacts of the ComMod processes carried out at the project key sites.

Figure 1.7 summarizes the implementation of PN25 project between 2006 and June 2010, and the following section of this report describes the objectives and main findings of the project regarding successively the development of a methodology to enhance the capacity of expression of the different stakeholders, the training of a small network of scientists and development officers engaged in collaborative modeling and simulation processes, and the analysis and mitigation of a series of concrete water and land management problems at the catchment level.

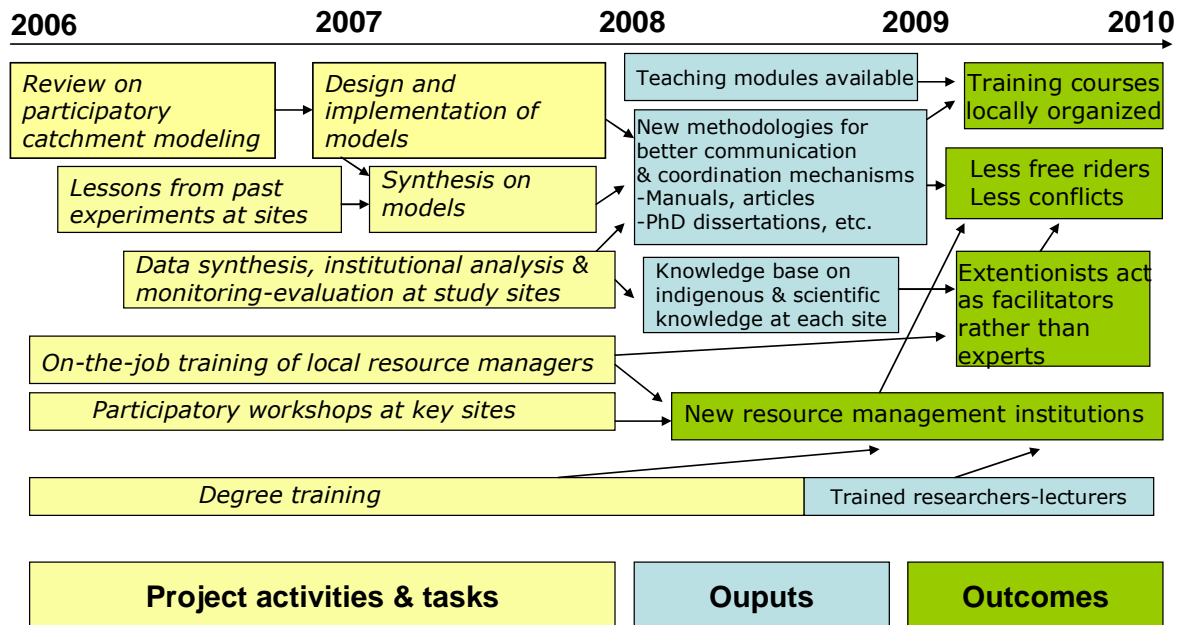


Figure 1.7: Timeline of project implementation, 2006-2010.

1. PROJECT OBJECTIVES AND MAIN FINDINGS

1.1. Objective 1: Methodological development in collaborative modeling and simulation

The project aimed at producing, testing, adapting and evaluating a collaborative modelling methodology and tools to enhance the capacity of expression of the different stakeholders to facilitate sharing of their perceptions about a common problem at stake in order to improve coordination and negotiation mechanisms among water users through the collective identification and assessment of scenarios of change leading to agreed-upon action plans.

1.1.1. Methods

The general principles of the ComMod approach were applied to build similar collaborative modeling processes at the project nine sites in three countries. The common framework in twelve steps displayed in Table 1.3 was built after Etienne & Bousquet (2009) and used to structure and describe these various collaborative modelling processes.

Table 1.3: Twelve steps framework to document ComMod processes.

Step	Step name	Definition & comments
1	Sensitizing activities	Introduction of ComMod approach to key stakeholders requesting to look into a given development-oriented question; assessment of suitability and feasibility to use it in the local context (included training session)
2	Definition of the key question	Problem identification & definition of the key question to be examined: done by the process leaders and, sometimes, other stakeholders too
3	Collection of information related to issue	Inventory of relevant scientific, expert, and indigenous relevant knowledge available through literature review & complementary diagnostic surveys to fill the gaps
4	Eliciting knowledge for modeling	Knowledge elicitation for modeling via surveys and interviews
5	Conceptual model design	Design of the conceptual model (specify if it is carried out with the concerned stakeholders, in lab., etc.)
6	Model implementation	Choice of the suitable tool (computer-based or not) and model implementation
7	Model verification, validation and calibration	Model verification, calibration and validation (specify if it is carried out with the concerned stakeholders, in the lab., etc.)
8	Identification and definition of scenarios	Identification and definition of the scenarios to be simulated with the local stakeholders
9	Exploratory simulations	Exploratory simulations of the selected scenarios with the stakeholders
10	Dissemination of outputs	Dissemination of the process outputs to stakeholders who did not participate in the ComMod activities so far
11	Monitoring-evaluation of effects of ComMod process on participants	Monitoring & evaluation of effects of ComMod process on the participants (change in awareness, knowledge, communication, behavior, decision-making, practices, etc.) and impacts (change in context, etc.)
12	Training of stakeholders	Training of stakeholders on using the ComMod approach and its tools produced during the collaborative modeling process

Much attention was given to the participatory characteristic of the modeling and simulation activities designed and implemented at each site with local stakeholders. A key original characteristic of the collaborative modeling and simulation methodology was to involve diverse types of participants in each ComMod process, most of the time with a majority of diverse types of farmers, including the usually voiceless ones such as resource-poor smallholders and women.

Series of field workshops with these concerned local stakeholders were organized to co-design models tailored to site specific questions, and at a later stage to simulate and collectively assess scenarios of change. These key moments of intensive collective interactions were systematically co-organized with the project partners in the field (development agencies, agricultural extension systems, conservation agencies, etc.). In these field workshops, successive plenary gaming and simulation sessions were associated with focus group debates to collectively analyze their results and make decisions about the following steps of the process, as well as individual interviews of participants to gather complementary information and assess the effects of the joint activities at the individual level.

The research team was well aware of the fact that the search of solutions to the complex water management problems examined at key sites should involve multi-level stakeholders' involvement in the processes. But because of important initial asymmetries in information, local power relations and the project goal of "leveling the playing field" by empowering marginal players, the choice was made to initiate every process with the actors at the grassroots level and to invite more powerful direct or indirect stakeholders only at a later stage and at the request of the villagers, when they felt ready for exchanges with them.

Each ComMod process relied on the use of successive versions of RPGs corresponding to changes in the focus of the process at the request of the participants in the process, and one or several versions of at least one associated ABM introduced after the gaming sessions. But the mode of association of these two key tools could differ among the nine sites depending on the process dynamics driven by the participating stakeholders. Nevertheless, in almost all cases, successive versions of RPGs were first used with the stakeholders in the initial ComMod cycles before the introduction of versions of the computer ABM allowing far more time and cost efficient simulations of scenarios identified by them in the previous steps of the process. This methodological choice was used to avoid the participants' fatigue in playing long (and costly to organize and manage) RPG sessions, and to make use of the rapid runs of simulations by the ABM to make more time available for the collective assessment of the results.

RPGs played a crucial role in all the processes to get the process started, break the ice among the diverse categories of participants, and initiate the exchanges of knowledge and perceptions about the water issue to be examined. In almost all the cases, the RPGs used a gaming board providing a more or less abstract representation of the catchment features relevant to the issue under study. When 3D block diagrams were in use, they also allowed joint map analyses sessions similar to the use of "folk GIS". The RPGs built were documented in Powerpoint presentations. During the design of the tools these slides were used to feed discussions between the PN25 team at a specific site and the project team of modelers. The final set of slides of each RPG was also used in training activities and as source of inspiration for the development of new RPGs.

While most of the time ABM simulations were used in the field with the concerned stakeholders to simulate scenarios of their choice, in a few cases, especially in Bhutan, the ABM simulations were limited to the exploration of multiple scenarios in the laboratory before to present some of them to the actors in the field. The standard

Overview-Design concepts-Details (ODD) protocol was used by the project team to document each ABM constructed during PN25 (Grimm et al. 2006).

Beyond these two key tools, a new kind called “hybrid simulator” was developed during the project. Based on a preliminary RPG, this computer simulator is able to replay gaming sessions *in silico* with a combination of actual and virtual players (Le Page 2009).

1.1.2. Results

Appendix A displays the chronograms of the different collaborative modelling processes implemented at each of the PN25 nine sites. Following their implementation, two main types of processes could be distinguished: in the first kind, the objective is mainly to elicit knowledge among the participants to co-construct a representation of the sub-system in which the problem under study is nested, while the second kind of ComMod process is mainly aiming at the facilitation of collective decision-making and the design of a concrete action plan. Figure 1.8 shows one example of each of these two types of processes.

Table 1.4 displays the full list of the models developed at the nine key sites and of their associated simulation tools, either RPGs or ABMs. In five sites, a single conceptual model was used to develop an RPG and later an ABM similar to the RPG. The initial RPG usually evolved with the successive (up to four) gaming sessions organized in the field. At two sites, two different models (differing by their focus or the arena of users involved) were built and translated in one RPG and two ABMs (in Kengkhar) or two RPG (one at the village level and the second one at both villages level) and two associated ABMs. In Mae Hae, three models gave birth to two RPG (depending on the focus) and two associated ABMs, while in Lingmuteychu three models were used to develop two RPGs (the first between two villages and the second one at the whole 7 village catchment) and three ABMs, including a final one to explore the effects of different theories in NRM on the system behavior. All together, a total of twelve RPGs and fourteen ABMs were constructed and used throughout the project. Each ABM built in the project is described according to the ODD standard protocol for the documentation of multi-agent system models to allow their replication (Grimm et al. 2006).

Diverse features were incorporated in the variety of RPGs built during the project: 2D or 3D gaming boards with varying degrees of abstraction, visualization techniques (especially the use of pictograms on a grid to facilitate the shift to the CORMAS interface of the associated ABM), light (simple calculator with an abacus) or heavy use of the computer (case of computer-assisted RPGs where the gaming board is electronically refreshed at the end of each round of play) in the gaming sessions. But in all cases, the RPG structure and rules remained flexible and adaptive to accommodate the numerous changes requested by the players. For example, in the case of Radi, following an initial introductory gaming session, the herders-players modified the spatial configuration of the gaming board proposed by the research team to better reflect their own perception of heterogeneities at the landscape level. While in Doi Tiew, the participants requested the addition of new features in the land use options proposed by the researchers to be able to test a major change in livestock rearing techniques. We also observed that relatively abstract gaming boards were well-accepted by the players as long as the key catchment heterogeneities related to the issue at stake were clearly represented. By allowing the players to envision new ways of managing the resources without sticking to the detailed actual circumstances at the site, this kind of board encouraged their creativity.

a. Lam Dome Yai site in Det Udom District of Ubon Ratchathani Province, Northeast Thailand

[illegible]

Legend: a: first RPG, b: second RPG and first ABM, c: second ABM & third RPG, d: third RPG, e: second ABM, f: third ABM, g: third fine tuned ABM (BMM model), h: participatory simulations with sample of farmers, meeting with PN25 research team, i: simulations with BMM model in the laboratory, j: participating farmers seminar at the Faculty of agriculture, UBU, m: Manitchara Thongnoi's M.Sc. defense, p: Warong Naivinit's PhD defense.

b. Lingmuteychu site in Punakha District, West central Bhutan.

[illegible]





Legend: a: training, b: trip to Bhutan, c: preliminary diagnosis, d: first RPG (2 villages), e: first ABM (2 villages), f: simulations in the laboratory, g: presentation, h: monitoring by local facilitator stationed at the research site, i: second RPG (7 villages), k: second ABM (7 village game), m: presentation to all the community, n: AKB post-graduate diploma, o: third & final ABM (7 villages).

Figure 1.8: Chronograms of ComMod processes implemented at Lam Dome Yai and Lingmuteychu watershed to elicit knowledge on land-water-rice-labor interactions and to facilitate collective management of resources respectively.

Table 1.4: List of models and associated simulation tools developed at PN25 nine sites.

Models designed in each site are representations of real systems referring to multi-agent systems. Most often, each model has been implemented as a role-playing game (RPG) and as a computerized agent-based model (ABM).


Bhutan

Lingmutyechu : 3 models (1 for 2 villages, 2 for 7 villages)		Chronogram : 
RPG for 2 villages	(1 session in May 2003, 1 session in December 2003)	
ABM for 2 villages	(used in lab only, April 2004)	
RPG for 7 villages	(1 session in April 2005)	
ABM for 7 villages (based on RPG)	(1 session in December 2007, 7 sessions in January 2008)	
ABM for 7 villages (theoretical)	(used in lab only, 2010)	
Kengkhar : 2 models		Chronogram : 
RPG	(1 session in April 2008)	
ABM (based on RPG)	(1 session in April 2009)	
ABM (theoretical)	(used in lab only, 2010)	
Radi : 1 model		Chronogram : 
RPG	(1 session in January 2006)	
ABM 	(used in lab only)	


Thailand

Mae Salaep : 1 model		Chronogram : 
RPG	(1 session in July 2005)	
Hybrid ABM	(1 session in August 2005, 3 sessions in October 2005)	
Mae Hae : 3 models (1 on land and forest, 1 on water, 1 on water and forest)		Chronogram : 
RPG on land and forest	(2 sessions in 2004)	
ABM on land and forest	(used in lab only)	
RPG on water	(4 sessions in 2005-2006)	
ABM on water and forest	(used in lab only)	
Nam Haen : 2 models (1 for a single village, 1 collective)		Chronogram : 
RPG for a single village	(2 sessions in June 2006)	
ABM for a single village	(1 session in September 2006)	
Hybrid ABM for a single village	(2 sessions in October 2006)	
Collective RPG	(1 session in December 2006)	
Collective ABM 	(1 session in December 2006)	
Doi Tiew : 1 model		Chronogram : 
RPG	(4 sessions from September 2008 to August 2009)	

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ABM	(in lab only, 2009-2010)
Lam Dome Yai : 1 model Chronogram : 	
RPG	(3 sessions from July 2005 to October 2006)
ABM	(4 sessions from April 2007 to September 2008, then used in lab)

Vietnam

Bac Lieu : 1 model Chronogram : 	
RPG	(3 sessions in 2006, 1 session in 2007)
ABM	(1 session in February 2009, then used in lab)

Updated (29 June 2010)

At Mae Salaep and Nam Haen sites of Northern Thailand, hybrid ABMs were developed to allow actual players to run simulations with virtual agents. In Nam Haen catchment of Nan province, Northern Thailand, such a tool was successfully used for out-scaling the ComMod process at the whole village community level. At this site government agencies aim at conserving the forest cover in upper watersheds through replantation schemes and the establishment of a new national park. Since the mid-90s, the delimitation of the park boundaries had been the subject of tensions between two Mien ethnic village communities and the officials from the Royal Forestry Department and mainly with the rangers of the National Park) as the villagers were fearing the prohibition of agricultural production and gathering of non timber forest products (NTFPs) in the reserved area. Along the ComMod process implemented at this site (Figure 1.9), the stakeholders' perspectives were integrated into five successive versions of a simplified representation of the system under study, with a new version inheriting from the previous one.

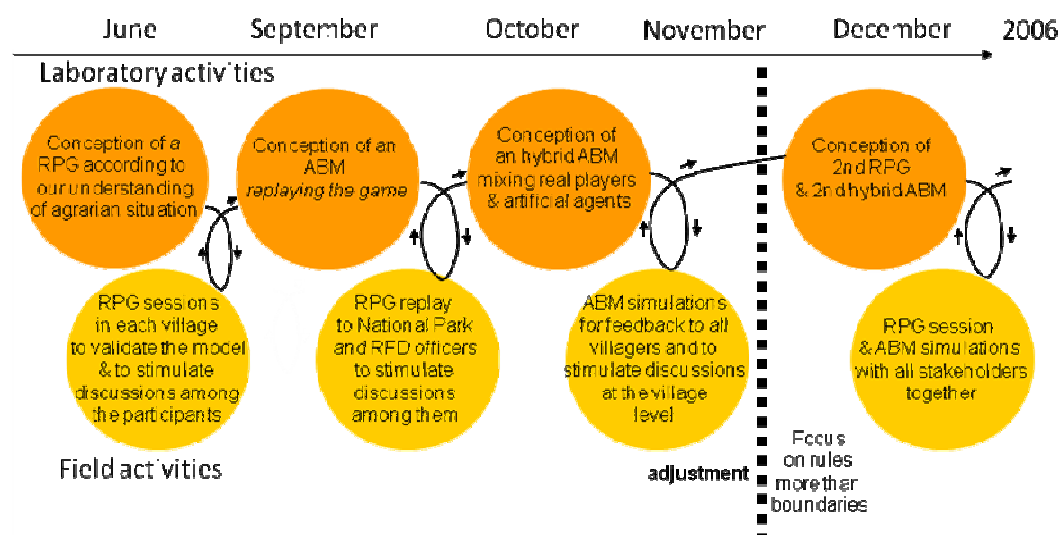
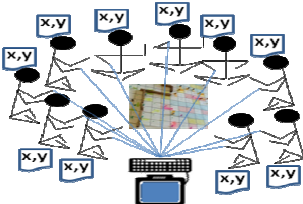
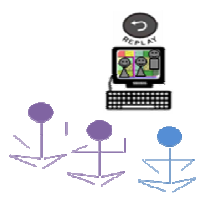
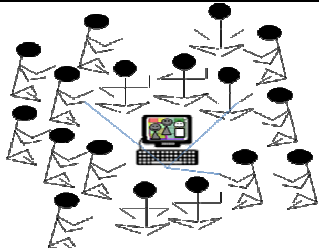
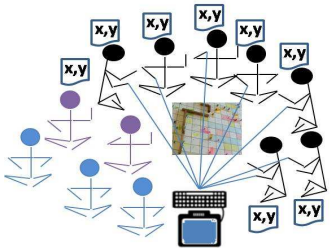
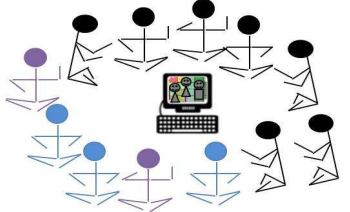


Figure 1.9: Chronology of the main phases of the ComMod process implemented in Nam Haen catchment of Nan province in Northern Thailand.

Version (change made compared to previous one)	Objective of the participative simulation workshop	Structure of the participative simulation workshop	Computer support and its functions*
First role-playing game (representation of the agrarian system by the research team)	In each village, to promote exchanges among 12 farmers playing their own role		Excel i. yes ii. yes iii. no iv. no v. no
« Replay » of RPG (computer agents reproduce players' decisions)	Show to national park rangers the RPG principles and the outputs of the 2 gaming sessions		Cormas i. no ii. yes iii. yes iv. yes v. yes
Hybrid computer simulation (simplified choice of crops)	In each village, increase size of groups of farmers to disseminate information to a larger audience (3 players & 9 computer agents)		Cormas i. yes ii. yes iii. yes iv. yes v. yes
Second role-playing game (the game board represents a larger area)	All stakeholders are able to talk about hot issues and to envision possible options for the future		Excel i. yes ii. yes iii. no iv. no v. no
Autonomous computer simulation	To explore and assess the scenarios identified by the stakeholders		Cormas i. no ii. yes iii. yes iv. yes v. yes

* Different functions of the computer:

- Inputing decisions made by human agents
- Calculating agents' performance-related indicators (actions)
- Simulating the resource dynamics
- Displaying the space (state of resources, agent locations, viewpoints of this space specific to each type of agent)
- Specification of agents' decisions by use of computer language.

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Figure 1.10: Comparison of the successive versions of the model developed at Nam Haen site in Nan province, Northern Thailand.

Figure 1.10 displays how these simulation tools, incorporating (or not) five different functions played by the computer, were associated along time to foster the development of a communication platform used to collectively explore and assess prospective scenarios of access rules to manage NTFPs (Le Page 2009). The ABM replying in silico the RPG gaming sessions performed with the villagers proved to be an interesting tool for up-scaling the process (in this case to attract the interest of the local Chief of the national park and his team). While the hybrid simulator proved to be an adapted tool for out-scaling the activities beyond a limited group of a dozen of farmers to the whole village community.

The implementation of similar processes at the different sites led to a kind of co-ownership of the model between the local stakeholders and the research team. The best example being the Ban Mak Mai (BMM) simulator developed in the Lam Dome Yai watershed with different types of rice farmers from that village. In this case, the villagers are now making presentations of “their” model to master students at the local faculty of agriculture, making explicit the choices they made in its construction and providing pertinent answers to questions raised by the students and their lecturers. At this level of improved capacity for communication of their points of view (at both the individual and group levels), one can see that a significant change has been made in the relationships between farmers and on-farm researchers or extension workers. Similar observations were made at other (Nam Haen, Mae Salaep, Mae Hae, and Doi Tiew) sites in Northern Thailand. The development worker based at Mae Salaep summarized this by saying that he can no longer do “business as usual” with the villagers who participated in the ComMod activities.

1.1.3. Discussion

The comparative analysis of the ComMod processes shows the very adaptive and flexible characteristic of the ComMod collaborative modelling and simulation activities, either when the objective is to better understand a complex collective water management system by building a shared representation of it (in three sites where the model is the key output of the process), or to facilitate collective decision-making by the concerned stakeholders (in the other six sites where the model supports the negotiation).

The chronograms displayed in appendix A show clearly that the time frame for the implementation of such collaborative modeling and simulation processes also need to be flexible as much depend on the participants’ availability, but also changes in the context. When a very supportive change in the context occurs, the process can take advantage of this and suddenly the pace of the activities accelerates. PN25 showed that managing many (nine here) similar ComMod processes in parallel in a structured project mode of operation is clearly not the best way to implement such activities.

The development of the methodology also clarified what is meant by “participatory (collaborative) modelling” or/and “simulation” by distinguishing between participation in the design, the co-construction of the model and participation in the use of the model. These different situations occurred at different PN25 sites with specific dynamics of participation and of the context along the process driving the evolution of the question to be examined and the related changes made in the simulation tools to be able to answer new stakeholders’ demands.

The RPG tool proved to be a versatile and pertinent one to elicit stakeholders' knowledge before to build ABMs as well as to facilitate communication and exchange of perceptions among them. At most of the sites, the participants liked this tool so much that many of them called the whole set of ComMod activities "the game". Sometimes (like in Lingmuteychu), the planned use of complementary ABMs with the stakeholders was not needed to reach collective decisions and produce agreed-upon action plans. But at other sites (like Nam Haen), the autonomous ABMs proved to be a useful and adapted for up-scaling the process beyond the village community. While hybrid simulators were found suitable for out-scaling the ComMod activities beyond a limited sample of villagers to the whole village population, especially at Nam Haen and Doi Tiew key sites.

The use of computer tools varied between sites and a gradient of computer tools was produced by the project. No major difficulty was found when applications relying on the Excel package were used to support RPGs (usually to accelerate some steps in the rounds of play and to record data at the end of each of them for further analysis). But the use of more sophisticated computer simulation tools required sharper programming skills to construct computer assisted RPG (cRPG, like in Doi Tiew case study) or hybrid simulators. In those case studies, the intensive support of the site coordinators by the experienced MAS modellers in the PN25 team was crucial.

With no exception, the representations of the bio-physical processes in the ComMod models developed, at each of the six sites where such a module was needed to represent the issue at stake, were simple ones. When a more sophisticated water models was available beforehand the early phases of the ComMod processes, it had to be simplified later on because the stakeholders were more interested to focus on other key aspects, especially the social ones. The tradeoffs between bio-physical, environmental, social and economic aspects were assessed through the quantification of at least two different indicators (usually one dealing with the bio-physical, ecological or environmental aspects of the water resource dynamics and another one looking at the economic or social ones) selected by the participants and used in the assessment of the proposed scenarios on a case by case basis.

From one ComMod cycle to the next one focusing on a different theme and/or involving a different arena of participants (switch from single village to 2, or more, up to 7 and 14 villages at Lingmuteychu and Mae Hae key sites respectively), such processes produce families of "disposable" models (see their lists for each site in table 1.2) used once and then usually discarded because they are not relevant anymore to answer the actors' new requests. Such collaborative modeling and simulation processes are demanding for researchers as they need to be very adaptive and responsive to the stakeholders' requests from a ComMod cycle to the next one. To sustain the process, modelers need to accept to produce models having a short life because they focus on local issues and take the contingencies of the local context into account. But some of these models could help to develop similar ones at other sites through fine tuning of existing models. In other cases, local and properly trained facilitators can continue to make use of these tools in other neighboring village communities facing similar water management problems.

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1.1.4. Conclusion

The implementation of ComMod processes at nine sites in three countries confirmed the suitability of this methodology for enhancing the capacity of expression of the different stakeholders' perceptions on diverse water issues, to facilitate their collective assessment of these problems, and to improve coordination among users through the collective identification and assessment of scenarios of change among stakeholders. At several sites, the project activities led to agreed-upon action plans on how to better share water resources and to their implementation during the duration of the project (see below under objective 3).

The methodology and specific tools developed under PN25 could be transferred elsewhere (see below the section on training activities under objective 2), including at larger scales in these or other basins. PN25 team is pleased to see that a new project adopting a similar approach is being prepared in the Volta basin of West Africa under the phase 2 of CPWF. Many of the above-mentioned lessons learnt by PN25 could be taken into account. In particular, we would recommend to incorporate more stakeholder analysis in the initial steps of such processes and a bolder multi-level approach.

1.2. Objective 2: Capacity building, contingent empowerment and trust building

The project proposed to train a regional network of young scientists and development officers for them to be able to become autonomous in the replication and dissemination of similar collaborative modelling and simulation processes relying on the methodology and tools developed and tested during the project.

1.2.1. Methods

At each site, the project collaborators were able to test and adapt the proposed common methodology by focusing on their interest, and to tailor its related tools at the sites according to their evolving needs.

The project organized (one or two week long) short training courses on the ComMod approach and its use, as well as more specific ones focusing on its tools such as role-playing games or multi-agent systems for collective resource management to help the project participants to improve their knowledge on collaborative modelling and simulation and their skills in the use of specific tools.

PN25 was also able to make use of an E-learning facility on ComMod and its tools, built during an EU funded Ecole-commod Project (See at: <http://www.ecole-commod.sc.chula.ac.th>). Collaborators used this internet-enabled learning and communication tool proposing a series of inter-dependent modules such as an initiation to ComMod, its fundamental principles, ComMod in practice, conceptual modeling with UML, multi-agent simulation, CORMAS simulation software, case studies, etc.

Degree training was provided to NARS partners in Bhutan, Thailand and Vietnam at Diploma, Master and PhD levels throughout the project.

Training materials produced during the project were gradually deposited in the « training » section of PN25 website (see at <http://www.cpwf25.sc.chula.ac.th>).

In the field, surveys carried out before ComMod activities, between each of the successive cycles and during the evaluation phase were also opportunities to provide further hands-on training. The same can be said about the several field workshops implemented at each key sites involving diverse stakeholders (farmers, resource managers, extension workers, administrators, etc.). Most of them were three or four-day long and the most frequent structure of such events is described in Table 1.5.

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Table 1.5: Structure and contents of a PN25 companion modelling field workshop.

Day / period	Main activity
- 1	Arrival at site: preparation, confirm appointment with participants, etc.
Day 1 - am	<ul style="list-style-type: none"> - Presentation of the workshop - Introduction of the main simulation tool, most frequently a RPG - First gaming & simulation session based on the current situation as baseline scenario - Participants propose, discuss modifications of the tool
Day 1 - pm	<ul style="list-style-type: none"> - Plenary on adjustment / modification of the tool as requested by participants - Second gaming & simulation session on a new scenario - Plenary debate on the results & suggestions for next steps
Day 2 - am	<ul style="list-style-type: none"> - Third gaming & simulation session with adjusted tool and/or on a new scenario - Plenary debate on the results & suggestions for next steps
Day 2 - pm	<ul style="list-style-type: none"> - Individual interviews with participants - Coding of the associated ABM in parallel
Day 3	<ul style="list-style-type: none"> - Individual interviews with participants - Coding of the associated ABM in parallel
Day 4	<ul style="list-style-type: none"> - Replay of a previous gaming session with the computer ABM tool - Identification and simulation of new scenarios with ABM tool - Plenary debate on the results & suggestions for next steps

At each key site, at least one of these field workshops was held per cycle of ComMod activities.

1.2.2. Results

Table 1.6 lists the six short training courses organized during the implementation of PN25 project. The last two-week course held at Chulalongkorn University in Bangkok assembled 20 trainees from 12 countries on every continent and was an opportunity to further disseminate the outputs from the project. The detailed contents of this course are presented in appendix B. This course made extensive use of PN25 case studies developed by the doctorate students. Positioned in the final part of the project and of their doctoral research, it was an excellent opportunity for them to play the role of trainers throughout these two weeks for them to learn how to prepare and execute such a training course. Following this key event, the training materials were put on the project website: recorded lectures, library of models, case studies, key references, etc. (see below the list of PN25 training materials). A similar approach was adopted with the Thai doctorate students during the previous short training held in Thai language at FNR-PSU Hat Yai campus in Southern Thailand. That event was also significant as a first attempt by the Thai PN25 partners to support the emergence of a new node in their national network at FNR-PSU in the Southern

region of the kingdom where a group of lecturers-researchers was interested to test the use of ComMod to examine land use change issues in irrigated systems of Nakhon Sri Thammarat and Phatthalung provinces.

This training event, also supported by the Echel Eau Project, was also a good opportunity to initiate linkages with colleagues working in other CPWF basins in China and Africa. In the second semester of 2009 and in the first semester of 2010, part of these training materials were also used in two “Ecole-chercheurs” (“Researcher workshops”) held for young professionals in Southern France, and another similar training event to be held in early 2011 is being planned in Montpellier, France.

Table 1.6: List of short training courses organized during PN25 project, 2006-2010.

Title	Location	Dates
In-country Training on Companion Modelling for Natural Resource Management	Natural Resources Training Institute (NRTI), Royal University of Bhutan at Lobeyasa	23-27 January 2006
In-country training on Multi-Agent Systems and the CORMAS simulation platform	Faculty of Science, Chulalongkorn University, Bangkok, Thailand	one week in September 2006
Introduction to Companion Modelling for ecosystem management	Faculty of Science, Chulalongkorn University, Bangkok, Thailand	17-19 October 2007
Training on Advance use of Companion Modelling for Natural Resource Management	College of Natural Resources (CNR), Royal University of Bhutan at Lobeyasa	6-11 December 2007
Introduction to Companion Modelling	Faculty of Natural Resources, Prince of Songkla University, Hat Yai, Thailand	26-31 January 2009
Companion Modelling for Integrated Renewable Resource Management	Faculty of Science, Chulalongkorn University, Bangkok, Thailand	11-22 May 2009

The organization of such training events has a very positive effect on the traffic observed on PN25 website as displayed in Figure 1.11.

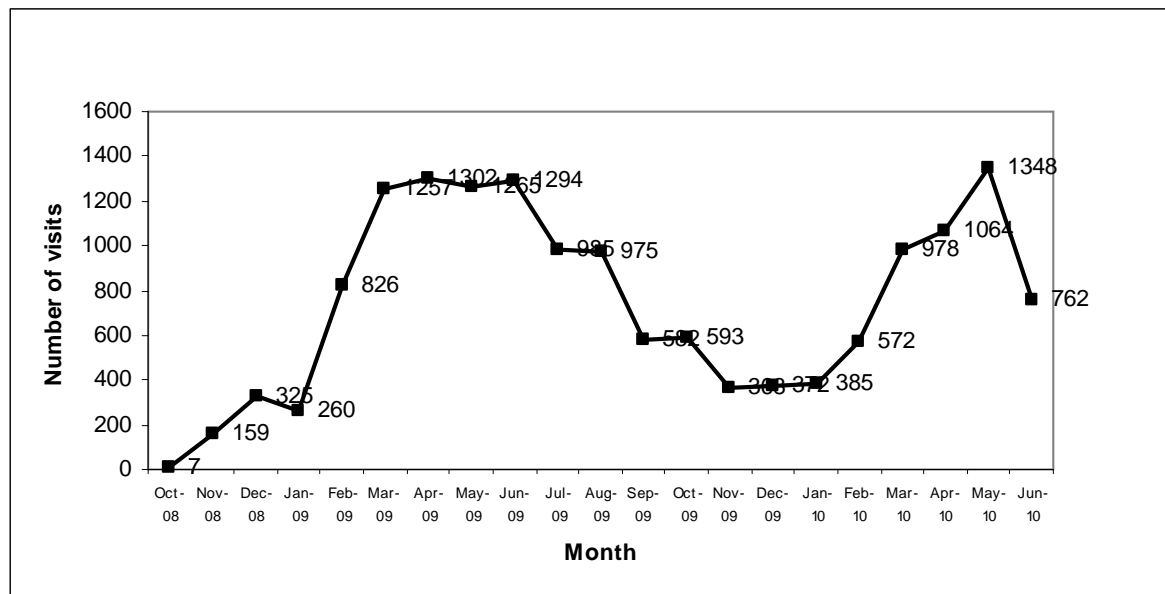


Figure 1.11: Monthly number of visits on PN25 website since its launch.

PN25 had a strong doctoral studies component with six site coordinators (3 Thais and one Bhutanese, French and Vietnamese each) undergoing their original doctorate research on subjects directly related to the project objectives and the central issues under study at their respective key sites. Two of them graduated under a joint-degree program between Paris Ouest Nanterre La Défense University, France (Human, economic and regional geography doctoral programme) and Chulalongkorn University in Bangkok, Thailand (Agro-technology PhD program). Three of them graduated at Paris Ouest University in France with the unanimous congratulations of the jury, and another one also obtained the top mark at Lyon University, France. Most of them have already published their key findings in peer-reviewed international journals (Barnaud *et al.* 2007, Barnaud *et al.* 2008, Dung *et al.* 2009, Naivinit *et al.* 2010, Dumrongrojwatthana *et al.* forthcoming) and the full text of their PhD dissertations are available on the project website at <http://www.cpwf25.sc.chula.ac.th> and on the global ComMod network website (see at: <http://www.commod.org/en>).

A Thai master student, Ms. Manitchara Thongnoi, was also supported by this project and the Echel Eau Project and graduated in the “Integrated farming” program at the Faculty of Agriculture, Ubon Rajathanee University (UBU), Thailand, in February 2009. Aita Kumar Bhujel, a Bhutanese collaborator from RNR-RC Bajo very much involved in the project activities at the Lingmuteychu site, was granted a diploma degree in “integrated watershed management” from Kasetsart University (KU) in Bangkok in May 2009. Finally, it is mainly in Bhutan where specific one-week training events could be organized in 2006 and 2007 for resource management officers (mainly crop, livestock and forest extension workers) to be aware of techniques and methods for participatory resource management.

A small regional network of ComMod users has been created during the project and is linked to two international ones: the ComMod network gathering people interested by this approach, and the CORMAS list of users of this MAS simulation platform. The innovative methodology and its key tools is currently being transferred to more

interested people through local institutions of higher education (Chulalongkorn, Chiang Mai, Ubon Rajatanee, and Cantho universities) were several PN25 site coordinators are teaching in Master programs following their graduations (at graduate level at CU, in M.Sc. & Ph.D. programs on modelling and participatory approaches at CMU, in undergraduate and graduate programs on information technology for agriculture at UBU, in the undergraduate program in agricultural extension at the CNR-RUB in Bhutan). Each member of this small network has stronger skills in a given area of the approach (model conceptualization, construction of RPGs, coding of ABMs in Smalltalk language under the CORMAS platform, etc.) and a kind of "division of labor" among them in the network is already in place. The network is also being re-inforced by other PhD students not formally included in this project but who are also doing their research on ComMod-related subjects at CU and FNR-PSU in Thailand.

1.2.3. Discussion

The comparative analysis of PN25 ComMod case studies on water management at the catchment scale also looked at participatory modelling and simulation as a way to empower people depending on their degree and timing of involvement in the process, on the composition of the arena of participants, the evolution of the context, etc. Different empowerment and trust building paths and drivers were found between case studies, depending on the context, history of the issue, and methodological choices in particular. This aspect was documented in details in the reports of external evaluations made at two Northern Thailand sites of Mae Salaep and Nam Haen (these reports are available on the project website) and the key findings were recently published in Barnaud *et al.* 2010

We observed that in all cases, the doctoral research implemented by the Asian students required more time than planned. In most cases, learning how to master the CORMAS simulation platform was a long and difficult task in spite of intensive support from the very experienced project MAS modellers throughout the duration of the project. Beyond this difficulty, the subjects of their research required system thinking, the adoption of an unusual research posture (compared to what they learnt before), a critical assessment of own work (a skill not developed in their academic background), and array of skills from group facilitation to the command of a computer modelling and simulation platform. This explains why at most key sites, the ComMod processes were long and relatively costly ones.

But at the end of the project, all the Thai and Vietnamese PhD students have graduated and are back in their respective faculties and universities where they use their new knowledge and its practical application in the field in teaching activities under appropriate undergraduate and graduate programmes.

Thai members of the project team have also been active in the recent creation of the ThaiSim Association of users of gaming and simulation tools in various fields, especially education. Complementary to the articles published in English, some of their key results are being published in Thai language in the association newsletter and its young journal. Le Canh Dung made a similar effort in the second semester of 2009 to make his findings available in Vietnamese language.

Over the years, the positive influence of other doctorate students in the group helped to reach the academic goal, to cement inter-personal linkages among them, and to nourish the envy to continue to do things together in the future. The strong doctoral

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research component of the project limited the time available for training activities aiming at resource managers in Thailand and Vietnam especially. In the case of Bhutan, where the links between the research team and development officers were stronger, such specific events could be organized and their contents were tailored to their different needs at two stages of project implementation (Table 2.2).

Apart from the new activities initiated in Southern Thailand in 2009, no new case studies were initiated by PN25 partners so far. But the existing ones developed under PN25 are much used in the global ComMod network and to illustrate lectures given by several project members in M.Sc. Programs at French universities in Paris (DYCODEV master program at Paris Ouest Nanterre La Défense University, in the Agronomy master program at AgroParisTech) and Montpellier (IDTR master program at Montpellier 3 University, and at the SupAgro "Institut des régions chaudes" – IRC).

1.2.4. Conclusion

The experience gained in managing this set of training activities and the results reported above show that, while they often slowed down significantly the implementation of the planned activities, training of partners to become autonomous in the use of the approach and tools is a necessary condition for lasting impact of the project beyond its completion.

Regarding the sustainability of the regional network of ComMod users, several positive aspects could be listed: it is linked to a global one and therefore will receive regular stimulation from the outside, a first concrete activity of the network in 2009 has been the support to the emergence of a new node at FNR-PSU in Southern Thailand, several site coordinators have confirmed their plan to continue to develop their case studies following their graduation and have requested or already obtained funding to do so. There is also a plan for introducing a similar approach in the phase 2 of CPWF in the Volta basin of West Africa.

1.3. Objective 3: Effects and impacts of ComMod processes for water management, institutions and catchment governance structures

Under this objective concrete water and land management issues at the catchment level, and stakeholders' interactions that are specific to the respective water-related problems identified in each context, were examined with the concerned actors. These participatory analyses led to the identification, simulation, and assessment of acceptable scenarios of (technological and organizational) adaptation to increase water productivity and its governance. The necessary conditions to create the desired situation were defined at several sites where joint action plans were prepared, and, in some cases were implemented during the project lifespan. At most sites, monitoring and evaluation (M&E) activities were implemented to document the effects and impacts of the ComMod processes implemented at those sites. In adaptive management of water at the catchment scale, M&E provides real-time feedback for constant creativity, learning and improvement of performance. Considering the complexity in INRM, effects and impact assessment and evaluation are indispensable for self-critical learning. M&E activities need to address the 'why?' questions and most importantly, what are the drivers that determine success or failure. Often the outcomes of interventions in INRM paradigm which happens over a period are influenced by other actors and factors (Campbell *et al.* 2001). Therefore, evaluation of INRM needs assessment within project cycles to support the learning of all stakeholders (including on-farm researchers) and supporting adaptive project management. Impact Pathway Evaluation (IPE) is an M&E approach that includes the processes by which stakeholders learn and negotiate based on evaluation findings (Douthwaite *et al.* 2003).

This section of the report draws heavily on the draft version of a joint synthesis article being prepared by the project team under the leadership of Tayan Raj Gurung. This paper is tentatively titled "Effects and impacts of ComMod processes: Comparative analysis of PN25 case studies".

1.3.1. Monitoring and evaluation framework

An important challenge was the integration of local and scientific knowledge systems. Thus the framework to support knowledge integration should incorporate tools to monitor and interpret outcomes of management actions, continually capture new information generated by research, transform it into useful knowledge, and monitor processes (Allen *et al.* 2001). As the ComMod approach is characterized by iterative, but evolving, cycles of sequential activities and procedures, an adapted monitoring and evaluation framework should capture the reflexive dimension along such very interactive process to understand why and how the approach worked to foster experiential knowledge (Jones *et al.* 2009). The framework used for evaluating participatory modeling proposed by Jones *et al.* (2009) was tailored to ComMod processes (Figure 1.12). It provides a frame to document the context, process, and to identify the sequence of methods and associated tools used and their anticipated effects. To capture the holistic understanding of the process effects and impacts, both project team and participants' experiences are documented and analyzed.

According to Webler (1999) social learning is a transformative process whereby changes in wider social context come about through people understanding their and

others interests, values, experiences, beliefs and feelings, and with this shared understanding act for collective good. Social learning process also delivers increased understanding of complex systems, more durable and equitable solution and increased capacity for active participation.

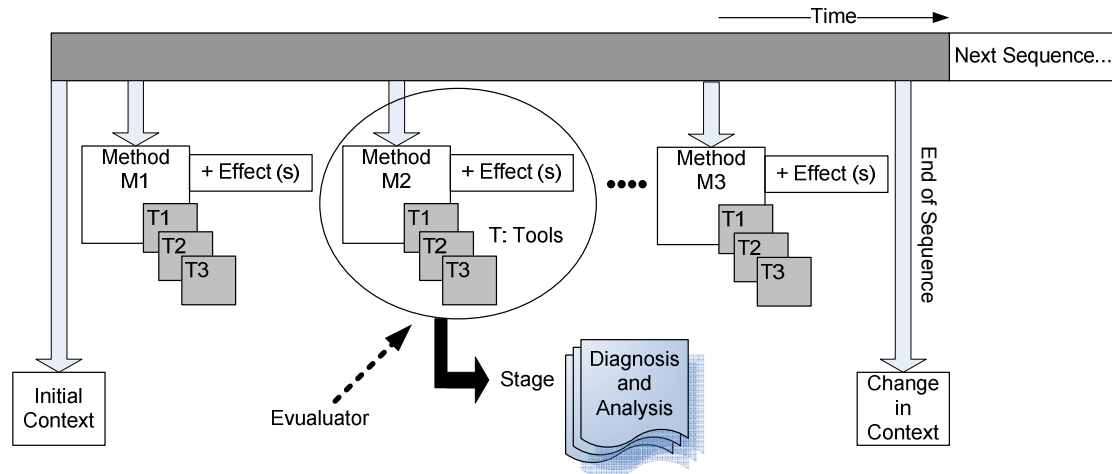


Figure 1.12: The monitoring and evaluation framework use in PN25 (adapted from Jones et al. 2009).

As ComMod is assumed to facilitate social learning, empowerment and transformation, monitoring and evaluation focused on learning and improving through an iterative process. Qualitative evaluation approach implies a focus on explaining the variation in perception and experiences, rather than proving cause-effect. Within the adaptive management paradigm, social learning aims to achieve the capacities to learn, reflect, and readapt the strategy and actions, which is otherwise “self-referenced”. Once self-referenced, the system will be able to reflect self-critically concerning the meaning of its actions enhancing its resiliency and perpetuate their own performance improvement (Hagmann et al. 2002).

The impact monitoring and assessment consist of three elements: process monitoring, outcome monitoring, and documentation of the process and outcome. Process documentation is considered as central for self learning; to demonstrate the quality of process implementation and impacts and/or outcomes; and to ensure that the rationale for adapting the planning framework was transparent and understood by all stakeholders. As a flexible and complex process associated with iterations, effects of ComMod approach are fundamentally created by actors, their values, responsibilities, power relations, and external factors. In views of its process orientation of ComMod, it is crucial to follow and track the events along the implementation framework so that process can be guided. Process monitoring is a blend of “impact-oriented monitoring¹” and “outcome mapping²” (Hummelbrunner,

¹ Monitoring is oriented on impacts throughout the entire implementation chain and therefore the likeliness of impacts can be already observed at early stages of implementation.

² Emphasis is placed on those outcomes, which are decisive factors for the achievement of results and can be directly influenced by a project: The quality of

2005) which supports continuous tracking of outcomes and impacts leading to generation of knowledge, promoting learning and capacity development.

As indicated in the monitoring framework (Figure 1.12) the benchmark for one sequence of the ComMod process can be considered as the initial context being changed into a new context. The initial context is documented either through literature reviews or participatory diagnostic studies, and considered as baseline. However with the difference in context across sites baseline information are generated through diverse tools and approaches. Context specific information related to the issues was generated through interviews and analysis of farm systems and stakeholders. In several cases typology of resource and users were established which could be used to analyse the trajectory of change.

With the engagement of researchers and players (mostly farmers) in the monitoring and evaluation process, it promoted participatory monitoring and evaluation. The participatory M&E ensures critical reflection and learning of both success and failures thereby stabilizing the organization. ComMod approach aims to provide progression from knowledge acquisition, either from within the group or external sources, to enhance better understanding of the problem individually and collectively. Such understanding helps in opening up communication and new networks to support collective decision-making through popular norms. In view of this gradual progression of knowledge acquisition to collective action, M&E of the ComMod processes emphasize interactive assessment of how the initial context evolves into a new state through use of sequences of methods and tools and accordingly build trajectories (Figure 1.12). These trajectories are a practical means to compare different cases.

In addition to change in the context, there are process effects which are of short, medium, and long term nature. Among several effects, the most pertinent one that brings about change in resource management regimes is the capacity development of those involved in the process. The capacity building can be perceived from four domains of technical capacity, personal or individual level, collective or social capital, and networking with outsiders.

As the research process followed the theory of participation, collective learning and actions, the intimate association of researchers, field workers, alongside the communities provided a pragmatic method to generate and consolidate information. Table 1.7 provides a summary of methods and tools used in nine sites. Because of practical and financial reasons, external evaluations could be done in only six sites. At the remaining three sites, the local coordinators did the work.

activities, organizational procedures, changes in the behavior of partners or target groups.

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Table 1.7: Methods and tools used to collect data for monitoring and evaluation.

Sites	Data Collection Method		
	Self Evaluation	External Evaluation	Logbook
Lingmuteychu	<input type="checkbox"/>	<input type="checkbox"/>	
Kengkhar	<input type="checkbox"/>		
Radi		<input type="checkbox"/>	
Bac Lieu	<input type="checkbox"/>		
Mae Salaep		<input type="checkbox"/>	<input type="checkbox"/>
Nam Haen Nan		<input type="checkbox"/>	
Lam Dome Yai		<input type="checkbox"/>	<input type="checkbox"/>
Maehae	<input type="checkbox"/>	<input type="checkbox"/>	
Doi Tiew	<input type="checkbox"/>		<input type="checkbox"/>
Tools	Questionnaire survey, interview and group discussion	Interview of participants and local farmers at research site, focus group and key informant survey, use of Most Significant Change (MSC) analysis and Actor Network Analysis (ANA)	Use of time series logbook to record exchanges, actions & decisions made by all involved at the research site
Implementer	Site coordinator	External evaluator with local translator or co-evaluator	Site coordinator

More or less sophisticated logbooks were assembled as Excel sheets at three sites to fully record all the interactions that occurred during the collaborative modeling and simulation process. The main window of the most sophisticated logbook developed at Doi Tiew site of Northern Thailand is shown in Figure 1.13.

At this site, the logbook data allowed to build diagrams of social networks with the Net Draw package to display the interactions among the participants along the whole process, on a cycle by cycle basis, or other types of diagrams focusing for example in the different types of knowledge exchanges during the whole process or a specific phase of it.

1.3.2. Results and discussion

A trajectory of change in the context can be roughly represented across sites in relation to severity of problem and scale at which the problem influences. Table 1.8 shows that, following the intervention with ComMod approach, there has been change in the context. Diverse courses are observed between sites as the intensity of change in context is linked to the main objective of the ComMod process. Where the main goal was to elicit stakeholders' knowledge and viewpoints to better understand the issue and represent it in an ABM, no change in the context due to these activities was expected (see Bac Lieu and Lam Dome Yai sites). At other sites, the ComMod aimed at improving collective decision-making and water management. In five sites (Lingmuteychu, Kengkhar, Nam Haen, Maehae and Doi Tiew) the severity of the problem decreased as this goal was more or less achieved. But in two sites, no such improvement was observed: in Mae Salaep the project ended with the village community still divided between two options to improve irrigation infrastructures in the catchment, while in Radi, where the ComMod process was a short one, its effects on the participants were less important compared to other, more powerful and well-funded, interventions aiming at the partial reforestation of these highlands.

a) Chronology sheet

Log book									
Doi Tiew case study, Nan Province, Northern Thailand									
Contact persons: Mr. Pongchai Dumrongrojwathana, Agricultural Technology Programme, Faculty of Science, Chulalongkorn University, and Department of Geography, Paris-x University									
Date	Duration (hr)	Organizer	Participants	Moderator /leader	Language	Type of activity	Objective	Location	Supporting tools or equipment
22-28/12/2007	108.00	PD	PD, WT, KR	PD	Thai	Ecological study	To study the impact of cattle grazing on forest regeneration in dry season.	Doi Tiew area	Ecological field equipments
25/12/2007	1.00	PD	PD, ST	PD	Thai	Discussion and request	To investigate the cattle population in village level by providing a simple questionnaire to primary school's childrens to interview their parent at home	Doi Tiew school	Questionnaire
9-11/01/2008	24.00	MCC,CMU	PD, conference colleague	MCC,CMU	English	International conference	To present "Companion modelling to facilitate adaptive forest management in Nam Haen sub-watershed, Nan Province, Northern Thailand".	Sheraton Hotel, Chiang Mai, Thailand	Computer
16/01/2008	4.00	Agricultural Technology program	Ph.D. students in Biological sciences and Agricultural Technology program	Seminar course organiser	English	Seminar	Proposal defence	Room 221, Biology Dept. Science Fac. CU	Computer
27/02/2008	1.00	PD	PD, AS	PD	Thai	Interview	To interview NKU chief on cattle raising and current situation (to fill the gap)	Nam Khang headquarters	Guidline for interview
27/02/2008	1.00	PD	PD, KerrSH	PD	Thai	Interview	To interview more information regarding cattle raising and current situation (to fill the gap)	Doi Tiew village	Guidline for interview

b) Actor sheet

Identification	Name	Institution	Position	Type of Knowledge	Speciality
PA	Pacharin Apiwan	NNP	Officer	institutionnel	conservation
KK	Kanya Kongkheaw	NNP	Officer	institutionnel	conservation
ThP	Theves Prarom	NNP	Officer	institutionnel	conservation
KI	Komsan Insri	NNP	Officer	institutionnel	conservation
AS	Anucha Sehreerat	NKU	Head	technique	forestry
PK	Pichet Kampatan	NKU	Officer	technique	forestry
SR	Suttipong Rangsee	NKU	Officer	technique	forestry
KT	Kittisap Tippala	NKU	Officer	technique	forestry
RP	Rabaeb Paeng-ud	NKU	Officer	technique	forestry
TP	Thanwa Paeng-ud	NKU	Officer	technique	forestry
JU	Jaron Upala	NKU	Officer	technique	forestry
MonT	Montri Tanakhwang	Healthcare	Head	technique	health
PachP	Pacharin Pano	SKRP	Head-Agriculture section	technique	agriculture
PrU	Prakob Ubprajak	SKRP	Officer	technique	agriculture
KS	Khwanchart Sirinya	SKRP	Officer	technique	agriculture
JN	Jak Namwong	SKRP	Officer	technique	agriculture
TunN	Tun Namwong	SKRP	Officer	technique	agriculture
TW	Tai Wongyai	SKRP	Officer	technique	agriculture
TN	Tawach Namwong	SKRP	Officer	technique	agriculture
SuP	Sujira Pano	SKRP	Officer	technique	agriculture
SK	Sakchai Korkerd	SKRP	Officer	technique	agriculture
US	Utid Srisitthipoj	LDD	Head	institutionnel	administration
SuK	Surapon Katewang	LDD	Officer	technique	administration
ST	Sanaoh Thepsen	School	Head	institutionnel	education
SB	Somjade Boontawee	School	Teacher	institutionnel	education

Figure 1.1: Main windows of the logbook used in in the Doi Tiew ComMod case study in Nan Province, Northern Thailand.

Table 1.8: Evolution of the context by way of ComMod process in nine sites.

PN25 site	Water issue	INITIAL CONTEXT		Nb. cycles	Years	FINAL CONTEXT	
		Severity	Scale			Severity	Scale
Lingmuteychu	Water sharing	Severe	Village	3	6	Medium	Catchment
Kengkhar	Water scarcity	Severe	Village	1	3	Low	Village
Radi	Grazing conflict	Severe	Catchment	1	1	Severe	Basin
Bac Lieu	Rice - Shrimp conflict	Low	Plot	1	3	Low	Plot
Mae Salaep	Irrigation water	Low	Village	3	4	Low	Village
Nam Haen	Use of forest products	Severe	Village	2	1	Medium	Village
Lam Dome Yai	Irrigation water & labor	Low	Village	4	4	Low	Village
Maehae	Irrigation water	Severe	Village	3	5	Medium	Watershed
Doi Tiew	Forest & grazing land	Severe	Village	1	3	Medium	Village

Capacity building

One of the tangible effects of the application of ComMod in nine sites has been the progressive build up of the individual and collective capacity to enhanced understanding of the problem, communication and manage the water management issues. The integration of local understanding, technical, expert, and scientific insights of the context into ComMod tools, and the interactive engagement of target communities in the process helped in progressively develop their capacity to better comprehend the water management problem and to act on it. Tables 1.9 and 1.10 present the effects related to capacity building recorded at PN25 nine sites.

- *Knowledge acquisition:* In all sites community members discovered dynamics of natural resource systems coupled with socio-economic context. Specific knowledge acquired related to agro-ecological (MH, LDY, DT, R, BL)³ technical (K, DT, NH), economic (MS, BL, R, L), social (R), and institutional (MS, NH, LDY, L, K).

³ Case study sites: L-Lingmuteychu; K-Kengkhar; R-Radi, BL- Bac Lieu; MS-Mae Salaep; DT-Doi Tiew, MH-Maehae; LDY-Lam Dome Yai, NH-Nam Haen.

- *Understanding and awareness of problem:* The initial knowledge helped in enhancing awareness about the complexity of the problem at all sites, and developed better understanding of the issues leading to identification of management options at seven of them (MS, NH, DT, MH, L, K, BL).

- *Change in perceptions:* The reflective insight and understanding of the complex issues changed the perception of participants in the way issue need to be appraised and handled. The new outlook removed the barrier of non-confidence (MS) for communication (NH, DT), networking (MH, L, R, BL), and decision-making (LDY, DT) thus promoting self-confidence both at the individual and collective levels.

- *Change in decision-making (individual, collective, institution):* When the community members have better understanding and perception of the issue, they engaged in information-based decision-making (MS), consultative negotiated process (NH, MH, K, R), management based (DT), and change in individual decision (L, LDY, BL) processes.

- *Change in behavior (individual, collective, institution, communication, networking and engagement):* The ComMod process as a neutral and non-confrontational platform promoted trust (DT) among actors and prompted disadvantaged groups to voice out at equal footing (NH). The process encouraged broad based consultation based on wider social networks and engagement in participatory consultation and collective actions (MS, MH, K, L, R, BL).

- *Change in action-practices-rules:* With the enhanced understanding, new perception and conduct, there was observable change in practices and actions. These changes can be segregated into individual, collective and institutional. Changes in individual practices were seen in Bac Lieu, Lam Dom Yai, Kengkhar and Radi where farmers started judicious resource use and networking. Collectively farmers of Mae Salaep, Doi Tiew, and Mae Hae organized to co-manage natural resources. But farmers in Lingmuteychu, Kengkhar, and Mae Hae created or reinforced local institutions as a means to improve management of water resources. In Lingmuteychu and Kengkhar sites of Bhutan, the ComMod activities facilitated the design and establishment of locally called "Watershed" or "tank network" management committees. Two supporting characteristics of the context in this country could explain why this was possible at these two Bhutanese sites: the availability of a national policy favouring community-based NRM and the joint implementation of the ComMod processes with the local agricultural extension system providing active site facilitator permanently based in those catchments.

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Table 1.9. Effects and outcomes generated by ComMod processes at five PN25 sites in Thailand.

Categories/Sites	Mae Salaep	Nam Haen	Lam Dome Yai	Doi Tiew	MaeHae
1. Knowledge acquisition Agro-Ecological, Technical, Economic Social, Institutional	Discover farm system dynamics, , pro-active information seeking (i), erosion control, farm budgeting (i)	Information on issue at stake (i), farm dynamics and land use strategies, implications of new park on livelihood (i)	Discover dynamic of farm system and importance of consultation on decision making.	Discover farm system dynamics, new cattle raising techniques, communication to mitigate land use conflict.	Land use, forest and water management inter-linkage (A/c)., constraints (E,S)
2. Understanding and awareness of problem	Better understanding of complex issue (i); Discover possible collective management options	Villagers learned about consequences of coming new land use regulations per type of farm (i)	Farmers awareness on intensive land-water use and the conflict on labour.	Awareness on lack of grazing land and improvement of cattle raising technique (i). Understand decision-making of herders.(i)	Up/Down stream water demand (i,c), linkage of factors, management options, Increasing in tension and conflict (i,c,l)
3. Change in perceptions • Own • others	Feel more confident in themselves, esp. resource-poor & female farmers (i)	Setup an atmosphere for mutual understanding (c)	Contrast between individual and collective operations in decision making.	Stakeholders understand need to negotiate to mitigate the conflict, and understand other decision-making process.	Need for negotiation (O), importance of individual and village network (c,l)
4. Change in decision-making (individual, collective, Institution)	Better farm management strategies, anticipation (i), seek for information more than before	Village headman use concentration mechanisms with farmers, stakeholders pledged to go for a co-management of NTFPs	Players changed decision-making at individual level.	Individually, herders trend to improve cattle raising technique by managing herd size. More anticipation to the future	Get district administrative officers and forester to involve in negotiation process. (c,l)
5. Change in behaviors (I,c,l); communication, networking and engagement	More discussion on issues, broaden social networks (i,c), More reflective behavior, Christian leader group more cohesive (c)	Poor households express their interest, encroachers refused to participate, Park official interested by information exchange	Promoted analysis, engagement others in consultation in resource management	Herders and foresters have better trust. Herders need their neighbour to participate the ComMod process.	Required further information related to the problem (I), bring issue into village meeting. (c,l)
6. Change in action/practices/rules (i,c,l)	Water sharing arrangement by few participants (c), Christian leader to design irrigation project, look for institutional support (c)	Agreement & villagers commitment to co-manage, and negotiate new regulations, Encroaching is still there	Decision-making on rice's growing techniques. Greater networking.	Co-management action plan on a 10 ha pilot establishment of <i>Brachiaria</i> forage plot between 2 herders and foresters.	Co-organized collective survey and discussion, intra-community discussion, continuation of negotiation effort (c,l)

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Table 1.10: Effects and outcomes generated by ComMod processes at three sites in Bhutan and 1 site in Vietnam.

Categories/Sites	Lingmuteychu	Kengkhar	Radhi	Bac Lieu
1. Knowledge acquisition Agro-Ecological Technical Economic Social Institutional	Benefit of sharing water across communities, Need for canal management, Maintenance of farm account	Study current systems of water management and sharing mechanism Explore scenarios of collective management and equitable sharing of the water resource	Enable conflict stakes for friendly interaction, Need for grazing land management, Common understanding for their own benefit	The ComMod activities enable local stakeholder to share knowledge of sustainable agriculture, understand the importance of rice component in rice-shrimp farming system
2. Understanding and awareness of problem	Players and observers become aware of severity of water shortage problem in Dompola	Participants analyze on results of different scenarios and create awareness among water users to opt for best options	Participants share each others problem, become aware on its implication on environment and the consequences	The participants raised awareness on collective discussion and cooperation on irrigation
3. Change in perceptions Own others	Water can be shared to others within village and with other village (ow)	Change in current perception of short term benefit self-centered orientation to sustainable use of water resource for better management	Swap roles puts one to stand on others shoe learning how they feel and what they need in contrast to their own thinking	The ComMod participants changed owns perceptions about threatening of shrimp monoculture and the conflict on water demand with rice producers.
4. Change in decision-making (individual, collective, Institution)	Individually farmers started to share by not holding excess water, build check dams, restoration of irrigation canals	Preference of collective decision making compared to individual decision in allocation of water resource	Participants learn what happens on what they do at individual level as well as collective and make decision accordingly	Players changed decision-making on individual level.
5. Change in behaviors (I,c,I); communication, networking and engagement	Free communication between villages of watershed (c), more interactions, easier water sharing	Facilitates open discussion communicating urgency of water need and therefore, equitable sharing and fair allocation	Act through better communication and networking systems, Need for negotiation to generate common regulation	changed to be more intensive thinking person and delivered ComMod activities to other villagers
6. Change in action/practices/rules (i,c,I)	Consultative process in up/down stream communities, earlier water release, restoration of rice field, acquired fund for watershed management (I)	Involves more interaction with generation of different ideas resulting to respect good ideas and putting into practice	Enhanced smooth way of communicating putting the conflict between the stakes and understanding each other	changed the decision-making on producing more rice than previous time

Lasting impact: Analysis of immediate & longer term effects

Considering that ComMod processes in most of PN25 sites had considerable influence on the knowledge, understanding and behavior of the participating farmers, it is useful to assess how far the approach impacted on immediate timeframe or how the researchers envision the impact. As most case studies focused on the various facets of specific water management it is appropriate to ascertain range of impacts on four domains of technical, individual (personal), collective (social), and external agencies (outsiders). Figure 1.14 summarises the immediate and longer term impact of these ComMod processes for these four domains.

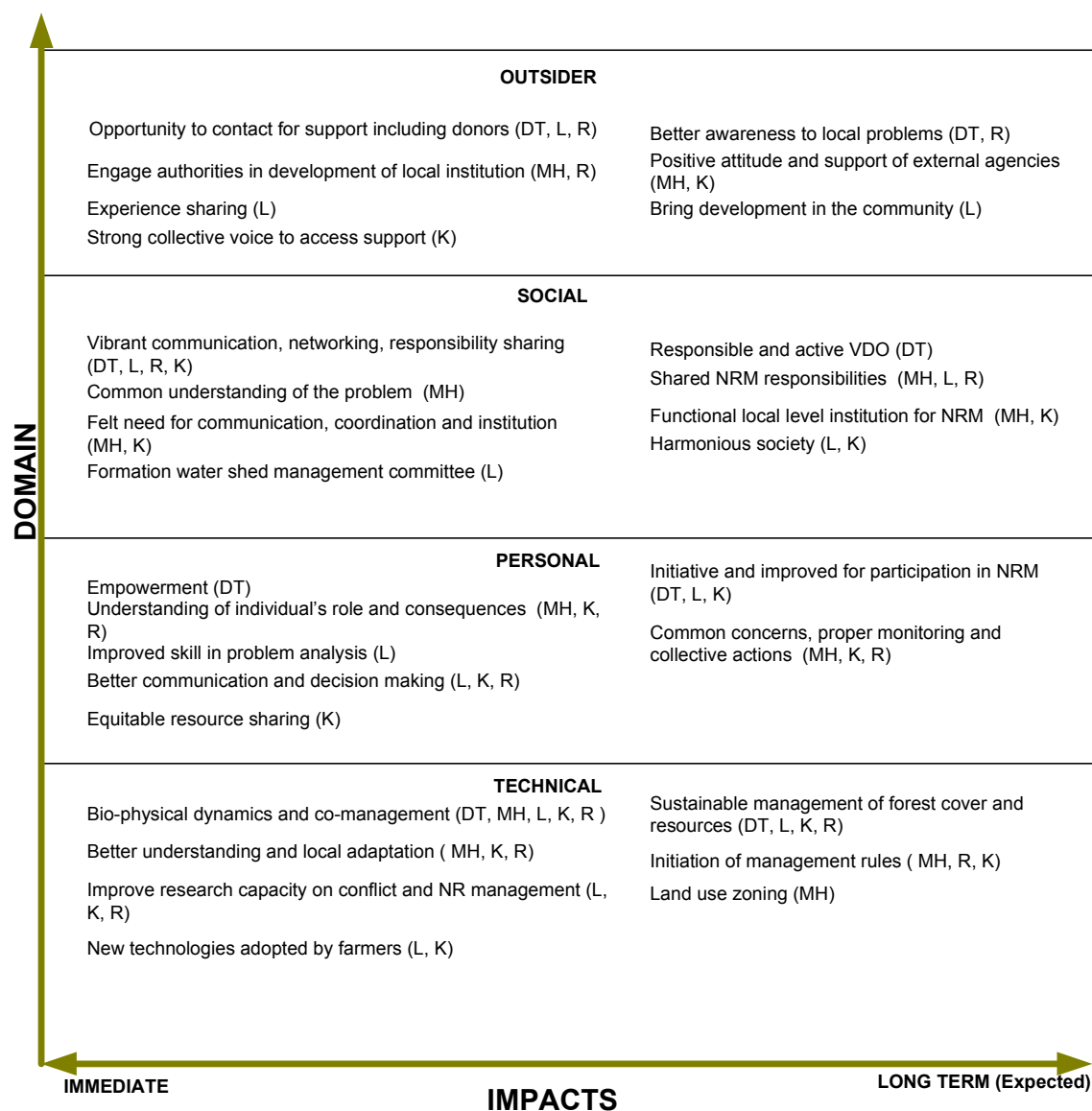


Figure 1.14: Immediate and Long term impact of ComMod approach.

- *Technical domain*: The immediate impact of the approach on technical domain was better understanding of the bio-physical dynamics, co-management and its adaptation to the local context. In case of sites in Bhutan, farmers rapidly adopted the technology of check dam construction, catchment protection and rain water harvesting. Further the process also helped enhance research capacity on natural resource management research and conflict management. In Mae Hae sites, the participating farmers agreed on the specifications of irrigation pipes to be used in the catchment, and in Mae Salaep

small neighborhood groups organized themselves technically to share limited irrigation water among several adjacent orchards belonging to different farms. While at Doi Tiew site, herders and foresters agreed to join their efforts in testing the feasibility of artificial pastures to limit the pressure on headwater areas. In Bac Lieu a new regime for the operation of sluice gates was agreed upon in order to manage the salinity level in the canals.

- *Personal (Individual) Domain:* The most prominent immediate impact has been the empowerment of individuals to better understand roles of different stakeholders and their consequences in resource management. Farmers acquired improved skill of problem diagnosis, and better communication and decision making for equitable resource sharing.

In the longer term, individual farmers are expected to have common understanding for monitoring and collectively managing the water and other resources. They also will have better (stronger) representation in public hearing and will be better positioned to take part in the preparation of new resource management policies. With the improved participation it is expected that people will take individual initiative for NRM.

- *Social Domain:* Collectively the community has coherent understanding of the problem and awareness which has promoted vibrant communication networking and responsibility sharing. In Mae Hae, Lingmuteychu, and Kengkhar cases, people felt the need for better communication, coordination, and institutional setting to support the local management of natural resources. At the end of the commod process, “watershed” management or “village network” committees were collectively planned and instituted in Bhutan, and reinforced in Northern Thailand.

In the longer term, responsible and functional local level institutions for NRM built on the basis of shared NRM understanding and responsibilities are expected from this process.

- *External Domain:* In all the nine cases a definite role of external agencies prevailed, if not lead the process. The process helped build cohesive community with collective voice to garner support from external agencies. As an immediate impact, the process ensured fruitful engagement of authorities in development of local institutions in the case of Bhutan. In Lingmuteychu, a major external donor, UNDP, agreed to fund the initial action plan designed by the new “watershed management committee”. They could also now represent their context and share experiences in meaningful ways to let others learn and also support the cause. In the long term, it is expected that external agencies will have a more positive attitude to the local problems and will extend necessary support in improving the local situations thanks to decentralization of NRM policies in particular.

Relevance of effects in relation with context & problem

The effects generated by the ComMod process in all sites are genuine and relevant to the specific context of each site. As the process interactively engages individual farmers (and other types of stakeholders) from conceptualization and design of research to conduct of research, up to the implementation of agreed upon action plans, there is tangible effect at different levels such as individual, collective and institutional. In addition there is also direct effect of the process on the bio-physical front.

Table 1.11 provides a summary of the direct effects of the process observed in nine sites by four levels. The most important effect of the process has been on the individuals whose awareness, understanding and capacity to comprehend the complex issue were significantly improved. The new found knowledge by participating farmers acted as the primary cohesive force to consolidate their common understanding to build trust, demystify the misconceptions of benefit sharing, promote consultation and collectively work to solve the NRM issues. In case of Lingmuteychu the process led to development

of a watershed management committee which has been operating for several years already. While in Mae Salaep, Mae Hae, Bac Lieu, and Kengkhar the need for new norms and local entity was expressed. In terms of the direct effect on bio-physical aspect, it was evident only in 3 Bhutanese sites where irrigation conveyance improved in Lingmuteychu, vegetative cover increased in degraded areas of Radi, and people started protecting catchment area of each springs in Kengkhar.

Table 1.11. Direct effects of the ComMod process across all sites.

Sites	Categories of Impact level			
	Individual	Collective	Institutional	Biophysical
Lingmuteychu	Increased awareness on managing irrigation water	Increased awareness of problem faced / other farmers	Creation of watershed management committee	Improved channel conveyance ,
Kengkhar	Water available for 2 additional months and reliable network	Participation in consultation and collective actions	Tank network management committee formed	Catchment protection
Radi	Adherence to grazing rules in degraded areas	Large scale catchment protection and maintenance	Existing NRM group takes up management as priority activity	Reduce soil runoff and improve vegetation cover
Bac Lieu	Awareness of ComMod methodology	Enhanced sharing of knowledge, dialogue and negotiation	Regulation on common water use between up and down stream villages	
Lam Dome Yai	Understanding on bio-physical dynamics help manage farming systems	Shared understanding& representation help in better resource use		
Doi Tiew	Awareness on improvement of existing cattle raising technique.	Improved trust and communication to mitigate land use conflict		Joint experiment on artificial pastures launched
MaeHae	Aware of interdependence of land-forest-water issue	Support to develop and introduce new land and water use rules	Awareness of need to widen communication to support community development	
Mae Salaep	Increased awareness on managing irrigation water	Shared understanding, representation help introducing new water use rules		
Nam Haen	Increased awareness of new park on agriculture	Aware of the need fo a village level dialogue to negotiate access to NTFPs	Joint agreement on communication platform signed by stakehodors	

Concurrently the process also had some indirect effects (Table 1.12) like individually farmer's pride of learning new research tools to manage NRM issue in Bac Lieu and removal of obstacles and opening of multiple windows for communication and information sharing help build social networks in the community. Thereby collectively they could initiate sustainable development activities. The congenial relationship individually also promoted open and productive proceedings of the management committees. In the bio-physical context, some of the indirect effects were introduction of technologies (like erosion control techniques in Mae Salaep site, or new cropping patterns in Maehae) as perceived from the RPG to improved social welfare as a means to sustain natural resources.

Table 1.12: Indirect effect of ComMod process in 9 sites.

Sites	Categories of Impact level			
	Individual	Collective	Institutional	Biophysical
Lingmuteychu	Individual farmer becomes open to new management	Respect for the need of other farmers	Less confrontation among communities	Improved social welfare
Kengkhar	Access to clean water, time saved from water collection	Social cohesion	Cooperation and understanding for collective action	Natural spring recharge enhanced
Radi	Respect for others resources	Better interaction		Plan for plantation in degraded areas
Bac Lieu	Pride on being aware of problem and means to solve	Promoting sustainable development	More attention paid to voice of local resource users	
Lam Dome Yai	Individual capacity to communicate and express themselves			Re-start to grow rice, direct seeding and farm ponds
Doi Tiew		Piloting forage pasture and application of tool to train neighbors	New regulation may set up when forage plot is established	Adoption of artificial pasture
MaeHae	Change in cropping pattern & farm management	Strengthen community unity and capability to manage	Restructuring & strengthening of the local village network institution	
Mae Salaep	Self-confidence of Akha women was boosted	Strengthening of group around the religious leader		Adoption of erosion control techniques
Nam Haen	Awareness of establishment of park on own farming practices	Awareness of the need for village level dialogue		

Factors influencing impact of ComMod approach

The pace and intensity of impacts of ComMod process in nine sites are dependent on various factors. The analysis of impacts in all sites provides a basis to segregate the factors into those enabling the impacts against those that impede the lasting impacts. Further it was also interesting to see that the factors were distinctly either internal, revolving within the community, or external which were linked to researchers or external agencies.

Based on the researchers' report, eleven factors that enabled the impacts of ComMod processes were found, while nine factors were identified as those impeding the influence of such processes (Figure 1.15). The severity of the problem and legitimacy of the team, supported by the ability to communicate and to interact were the two major enabling factors linked to community. While the reactivity of local leaders, the engagement of knowledgeable elders, and the implementation of collective actions were also identified as internal enabling factors. Externally, the frequency of researchers' interactions with the stakeholders and the provision of external support played major roles in influencing the ComMod impacts. Similarly, the historical perspective of the conflict did provide some influence on impact. Other factors like knowledge sharing between researchers and farmers, use of tools and research-extension linkages also had some control over ComMod impact.

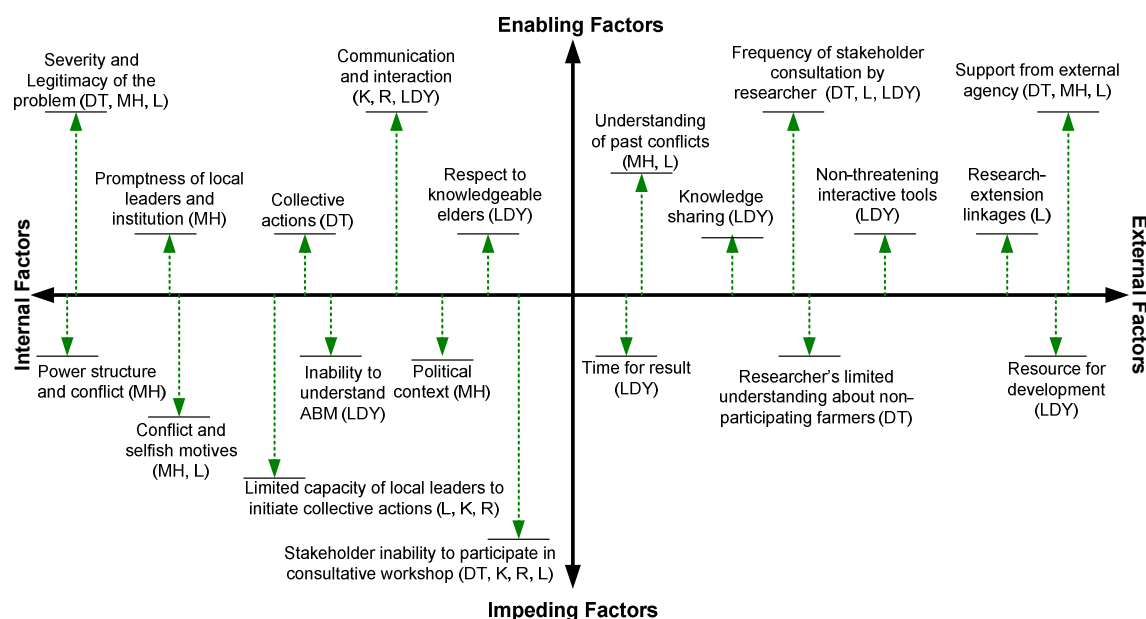


Figure 1.15: Factors facilitating and impeding impacts of ComMod processes.

Complementary to the enabling factors, there were nine factors experienced across sites that curtailed the fullest impact of ComMod processes. Among them the non-participation by some concerned stakeholders in the process and the limited local capacity to initiate collective actions were experienced in several sites. These factors including on-going conflict, power structure, local politics, or the inability to understand some tools (like ABMs) were factors associated to internal situations. Externally resources for development-oriented actions, time to see the results from technical inputs and limited understanding of non-participating farmers were observed in three instances as impeding factors.

1.3.3. Conclusion

The application of ComMod approach in these contrasting situations provided a unique opportunity to compare its effects and impacts within a common framework. Despite the diversity of contexts, ComMod process provided a suitable methodological approach to support knowledge acquisition at individual, collective, institutional, and bio-physical level. It also facilitates behavioral change to communicate, network and collectively work towards building adaptive mechanisms to adjust in a dynamic ecosystem to manage an array of specific conflicts over water management.

In view of the focus of research being various facets of natural resource and their management, ComMod process had both immediate impact on four domains of technical, individual (personal), collective (social), and external agencies (outsiders). These immediate impacts acted as an incentive for participating farmers to commit their time in the process. Some of the tangible immediate impacts were solution-based such as direct seeding, check dams, size of irrigation pipes, water reservoirs and their network, fodder grass, tea plantation, and many more. In the longer term, it is expected that ComMod process will impact on the widening the scope of communication and networking thereby reinforcing the social fabrics. This could already be observed at Lingmuteychu site where the new local institution development-oriented initiates actions beyond water management *per se* like the protection of springs and steep slopes.

As the process interactively engages individual farmers (and other categories of concerned stakeholders) from conceptualization and design of research to its implementation and the execution of concrete action plans, there are tangible effects and impacts at different levels such as biophysical, individual, collective and institutional. Further models and scenarios allowed people to step out of their real setting thereby enabling stakeholders to realize the problems both from insider point of view and outsider perspectives. While it takes time (multiple cycles were needed in most in case studies), ComMod creates space for integrating knowledge and viewpoints leading to trust in relationship between stakeholders. This is important because the project team assumed that building up trust and legitimacy along the process could boost the chance to achieve the desire outcome of the participatory modelling process.

As it is the case with many participatory approaches, the success of ComMod approach depends on factors like severity of the problem and legitimacy of the group of participants, supported by the ability to communicate, promptness of local leaders, engagement of knowledgeable elders, and implementation of collective actions, all being important enabling factors. As in all case studies, the role of researchers in facilitating the process was one of the major external factors that enabled the process. In the same manner, the impact of ComMod process was hindered by non-participation by some key stakeholders in the process and limited local capacities to initiate collective actions were experienced at several sites. Additionally on-going open conflict, asymmetric power structures, local politics, and the inability to understand some of the sophisticated tools that were introduced were found to be other limiting factors associated to internal situations.

Although ComMod approach has been known for its flexibility in adaption to local situations, the core of the approach still is the CORMAS simulation platform, which demands special skills to program in Smalltalk language. As indicated by the farmers in case studies, the time it takes to generate scenarios and lack of insight of the process could be a methodological hurdle. Further as ComMod approach capitalizes on the iterative processes, the validity of the feedback can highly influence the outcome of the ComMod approach. With the orientation of ComMod approach as a process featuring iterative cycles of participatory methods and tools, it is imperative to closely monitor the

process to distinctly identify and assign the outputs, effects and impacts to specific methods and tools.

With the identification of factors influencing the impact of ComMod approach, the challenge remains on how to make the simulation platform more user-friendly, and to motivate all the concerned stakeholders to take part in the collective process. Considering that the ComMod cases studies report of generating original knowledge, perception and behavioural change to collective actions, yet another challenge can be to study and establish the scope and sustainability of those effects and impacts.

OUTCOMES AND IMPACTS

This portion of the study focuses on how the project has influences local stakeholders at the different PN25 sites to effect change.

2. Outcomes and impact proforma

Summary Description of the Project's Main Impact Pathways

Bac Lieu site, Mekong Delta, Vietnam

Actor or actors who have changed at least partly due to project activities	What is their change in practice? I.e., what are they now doing differently?	What are the changes in knowledge, attitude and skills that helped bring this change about?	What were the project strategies that contributed to the change? What research outputs were involved?	Please quantify the change(s) as far as possible
Farmers who participated in PN25	They adjusted their water salinity requirement that could minimize impacts to other farmers, and they adjust land use - They grow rice in shrimp ponds in the wet season	They understand the effects of water control at the system level rather than at the farm level only – Now they also understand the benefits provided by the rice component in their farming system	- The selection of up- and down- stream villages - Inviting both husband and wife to participate - Village level workshops, then joint workshop	Approx. 20 farmers
Provincial and local government officers responsible for land use and water control	They adjusted their land use plan and operation of salinity control sluices	They better understand land use change and water need of different types of farmers at different locations	- Explained the project and got the permission to work in the area - We invited them to observe the workshops, gradually from low/field to higher levels	10 officers.
Other farmers	They adjusted land use	Reactive adjustment	None [indirect effect]	Numerous

Other Provincial and local government officers in the coastal region of the Mekong Delta	Thinking about sustainable agricultural development of coastal areas	They better understand land use change and the needed adjustment in water management	Invitation to participate in seminar and conference	Not quantified
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Of the changes listed above, which have the greatest potential to be adopted and have impact? What might the potential be on the ultimate beneficiaries?

- Similar adjustment of water requirements could occur in other provinces facing the same salinity control system leading to more land use change by farmers.
 - Coastal farmers could grow more rice and include other components in their farming systems, rather than only shrimp monoculture, to minimize risk.
 -

What still needs to be done to achieve this potential? Are measures in place (e.g., a new project, on-going commitments) to achieve this potential? Please describe what will happen when the project ends.

Train scientists at local university to engage officers of other irrigation systems. This was initiated in September 2009 with a seminar at the Mekong Development Institute (MDI), Cantho University, and a workshop in the Mekong Delta could be considered as another initial training event.

Each row of the table above is an impact pathway describing how the project contributed to outcomes in a particular actor or actors. Which of these impact pathways were unexpected (compared to expectations at the beginning of the project?)

We did not expect that the adjustment of water quality would be quickly adopted by local farmers.

Why were they unexpected? How was the project able to take advantage of them?

The initial assumption was that this would be difficult to change the existing practice because farmer would try to maximize shrimp farming and the generation of cash income.

What would you do differently next time to better achieve outcomes (i.e. changes in stakeholder knowledge, attitudes, skills and practice)?

Lam Dome Yai watershed in Ubon Ratchathani Province, Lower Northeast Thailand

Actor or actors who have changed at least partly due to project activities	What is their change in practice? I.e., what are they now doing differently?	What are the changes in knowledge, attitude and skills that helped bring this change about?	What were the project strategies that contributed to the change? What research outputs were involved (if any)?	Please quantify the change(s) as far as possible
Small rice growers from Ban Mak Mai village in Det Udom District	<ul style="list-style-type: none"> - Construction of new on-farm ponds - Improved management of rainfed lowland rice (RLR) management - Re-start to grow rice growing 	<ul style="list-style-type: none"> - Knowledge of rainfall distribution - Integrated farming practice - Knowledge of labor migration patterns in the village - Improved communication skills & larger social networks 	<ul style="list-style-type: none"> - Inclusive selection of participants covering the range of existing farm types in the village - Invitation of husband and wife to attend the field workshops - Frequent interactions between farmers and the research team 	<ul style="list-style-type: none"> - 5 households - 3 individual farm ponds
Medium to large rice growers from Ban Mak Mai village in Det Udom District	<ul style="list-style-type: none"> - Initiate farm accounting - Grow more rice varieties to better adjust to water dynamics and labor scarcity 	<ul style="list-style-type: none"> - Relationship between rainfall and water level in field & pond - Impact of labor shortage on rice production & paddy quality - Water dynamics in relation to rice production - Improved communication skills & larger social networks 	<ul style="list-style-type: none"> - Specific settings to stimulate interactions - Co-design and use of inter-related simulation tools in parallel 	3 households

Of the changes listed above, which have the greatest potential to be adopted and have impact? What might the potential be on the ultimate beneficiaries?

Improvement in participating farmers' communication skills through the co-design and use of inter-related simulation tools to express their demands.

What still needs to be done to achieve this potential? Are measures in place (e.g., a new project, on-going commitments) to achieve this potential? Please describe what will happen when the project ends.

Continue to support the participating farmers through knowledge exchange activities to tackle new issues of interest to them (e.g. marketing of agricultural products and diversification out of rice) thanks to the recent submission of a new research proposal to apply the ComMod approach to understand human-environment interactions in an irrigated area of lower Northeast Thailand.

Each row of the table above is an impact pathway describing how the project contributed to outcomes in a particular actor or actors.

Which of these impact pathways were unexpected (compared to expectations at the beginning of the project?)

- Resource-poor smallholders invested cash to construct new farm ponds.

Why were they unexpected? How was the project able to take advantage of them?

- Usually smallholders have very little investment capacity and are reluctant to convert part of their tiny holdings into farm ponds.

What would you do differently next time to better achieve outcomes (i.e. changes in stakeholder knowledge, attitudes, skills and practice)?

I would include an economist in our research team to integrate the economic dimension of the issue being examined in the co-design and use of inter-related simulation tools.

Maehae site, Chiang Mai Province, Northern Thailand

Actor or actors who have changed at least partly due to project activities	What is their change in practice? I.e., what are they now doing differently?	What are the changes in knowledge, attitude and skills that helped bring this change about?	What were the project strategies that contributed to the change? What research outputs were involved (if any)?	Please quantify the change(s) as far as possible
Maehae farmers who participated in PN25 activities	<ul style="list-style-type: none"> - Cropping pattern to reduce risk of price fluctuation and water shortage - Water sharing among neighboring farms and at the catchment level 	<ul style="list-style-type: none"> - Understanding of others' practices and constraints - Higher capacity to communicate - More comprehensive understanding of their own farm practices - Better awareness of interdependency of land-water-forest issue 	<ul style="list-style-type: none"> - Putting these actors in situation through interactive simulation exercises 	- Not quantified
The village network (the local institution dealing with NRM issues)	<ul style="list-style-type: none"> - Took action to set up new land and water use rules 	<ul style="list-style-type: none"> - More aware of interdependency of land-water-forest issue - Learnt how to facilitate meetings to achieve deeper and multi-level involvement of participants 	<ul style="list-style-type: none"> - Provided support in facilitating workshops - Strengthening of this local institution 	1 network of 14 villages
Community leaders (village committee members)	Took action to set up and to support the implementation of new land and water use rules	<ul style="list-style-type: none"> - Same as above and - Got a better understanding of the water use conflict 	<ul style="list-style-type: none"> - Advice on how to organize the whole process - Personal engagement in collective activities - Provision of artifacts (maps, VDO, etc.) at proper time 	Several village leaders in 14 villages

Of the changes listed above, which have the greatest potential to be adopted and have impact? What might the potential be on the ultimate beneficiaries?

- Improved cropping pattern toward more adaptive farm, and resource-sharing management.
- Less vulnerable to market price and climatic fluctuations.

What still needs to be done to achieve this potential? Are measures in place (e.g., a new project, on-going commitments) to achieve this potential? Please describe what will happen when the project ends

- Institutionalization of interactive workshops to foster collective thinking and exchange of practices.
- The committee leaders need to keep enforcing the implementation of the agree-upon resource use practices.
- Young extension workers should be trained at the university to be able to replicate similar processes.
- No measures in place yet.

Each row of the table above is an impact pathway describing how the project contributed to outcomes in a particular actor or actors.

Which of these impact pathways were unexpected (compared to expectations at the beginning of the project?)

- Adaptive cropping pattern management of individual farmers to reduce exposure to price fluctuation.

Why were they unexpected? How was the project able to take advantage of them?

- The issue was not identified at the initial stage, but the individual participants intuitively elaborated this outcome after participating in the simulation exercises.
- The project did not take advantage of this positive side effect [not the focus of this case, but such unexpected side effects are common in open ComMod processes].

What would you do differently next time to better achieve outcomes (i.e. changes in stakeholder knowledge, attitudes, skills and practice)?

Better mobilization of local resources (institutions, laws, authorities) to enforce the agreement on new land and water rules.

Mae Salaep site, Chiang Rai Province, Northern Thailand

Actor or actors who have changed at least partly due to project activities	What is their change in practice? I.e., what are they now doing differently?	What are the changes in knowledge, attitude and skills that helped bring this change about?	What were the project strategies that contributed to the change? What research outputs were involved (if any)?	Please quantify the change(s) as far as possible
Three categories of Mae Salaep farmers who participated in PN25 activities	<ul style="list-style-type: none"> - Irrigation water sharing among neighboring farms - Adoption of soil erosion control measures to reduce risk of land degradation - Group design of a village project to develop water storage infrastructures for submission to donors 	<ul style="list-style-type: none"> -Communication : larger social networks, seek answers outside of the village - Improved self-confidence of Akha women: realize they can influence decisions & plan to organize themselves, join the group around the religious leader - More comprehensive understanding of their own & others farm practices 	<ul style="list-style-type: none"> - Use of interactive simulation exercises focusing on 3 successive farmers' topics of interest - Carried out two initial ComMod cycles with farmers only before to involve the sub-district administration (a potential donor) - Tactical choices to facilitate the expression of voiceless Akha women, like small group simulations before plenary sessions 	12 farming households
The village development workers	<ul style="list-style-type: none"> - Manage differently the farmers who took part in activities (found "more demanding", "better informed") and other households 	<ul style="list-style-type: none"> - More aware of the water use conflict between two clans in the village - Learnt how to facilitate field workshops 	Worked through them to prepare and implement every field workshop	2 development officers

Of the changes listed above, which have the greatest potential to be adopted and have impact? What might the potential be on the ultimate beneficiaries?

- Improved self-confidence and assertiveness of participatory farmers, particularly the Akha women managing small resource-poor holdings. If they succeed in getting their project funded, irrigation water at flowering will be available in most of the village farms to stabilize litchi yields, improve fruit quality and allow the production of high value Oolong tea.

What still needs to be done to achieve this potential? Are measures in place (e.g., a new project, on-going commitments) to achieve this potential? Please describe what will happen when the project ends

- Find an alternative donor, following the rejection of the project designed by the villagers by the sub-district administration because of a conflict of interest.
- The villagers are in touch with alternative sources of funding.

Each row of the table above is an impact pathway describing how the project contributed to outcomes in a particular actor or actors.

Which of these impact pathways were unexpected (compared to expectations at the beginning of the project?)

- The adoption of erosion control measures by several participants to limit land degradation was unexpected as this topic was not directly dealt with in the ComMod activities.

Why were they unexpected? How was the project able to take advantage of them?

- During interviews with the external evaluators, these participating farmers insisted that this was an indirect outcome of the modeling and simulation exercises because they continued to discuss their results between field workshops (i.e. in the absence of the research team) and those exchanges led to reconsider the adoption of soil erosion control measures.
- The project did not take advantage of this unexpected positive and indirect outcome, not directly related to the central irrigation water sharing issue, but such unexpected side effects are common in open ComMod processes.

What would you do differently next time to better achieve outcomes (i.e. changes in stakeholder knowledge, attitudes, skills and practice)?

- Be more aware of the possible lack of accountability of the village representatives and President of the sub-district administrative organization and manage the ComMod process accordingly.
- Do more to ensure continuous support to this community after project termination through the regional university.

Nam Haen site, Tha Wang Pha District, Nan Province, Northern Thailand

Actor or actors who have changed at least partly due to project activities	What is their change in practice? I.e., what are they now doing differently?	What are the changes in knowledge, attitude and skills that helped bring this change about?	What were the project strategies that contributed to the change? What research outputs were involved (if any)?	Please quantify the change(s) as far as possible
Farmers from 2 Mien (Yao) villages who participated in PN25 activities	<ul style="list-style-type: none"> - Gathering of non timber forest products (NTFPs) in the area of the new National Park - Agreement to negotiate new access rules between the villagers and the representatives of government agencies (Royal Forestry Department – RFD- and rangers from Nanthaburi national park) 	<ul style="list-style-type: none"> - Better awareness of the implications of the establishment of a new national park to protect the forest in head water areas on their collection of NTFPs practices - Better communication between villagers, RFD foresters and park rangers - Better understanding of the importance of NTFPs for poor households by village headmen 	<ul style="list-style-type: none"> - Use of interactive simulation exercises based on a role-playing game to raise the awareness of villagers on the consequences of the installation of the new national park on their farming and NTFP gathering activities. - Use of an hybrid simulator to out-scale and up-scale the results of the field workshops 	Households from two villages (minus the several ones who are encroachers and who refused to participate in the proceedings)
Representatives of government agencies: foresters from the RFD and rangers from Nanthaburi national park	<ul style="list-style-type: none"> - Signed an agreement with villagers to manage the forest-farmland interface in a negotiated way 	<ul style="list-style-type: none"> - More aware of the economic importance of NTFPs for local resource-poor households - Learnt how to facilitate field workshops 	<ul style="list-style-type: none"> - Worked through the local RFD unit throughout the ComMod process – Involved the national park rangers in a second stage only because of their more negative perceptions by the villagers 	Several officers from each of these 2 agencies

Of the changes listed above, which have the greatest potential to be adopted and have impact? What might the potential be on the ultimate beneficiaries?

- An agreement to jointly manage the resources along the local forest – farm land interface was formally signed by all parties involved.
- This agreement could lead to continuous access to NTFPs by the most vulnerable farming households based on a new set of agreed upon rules.

What still needs to be done to achieve this potential? Are measures in place (e.g., a new project, on-going commitments) to achieve this potential? Please describe what will happen when the project ends

- More support to the local actors is still needed to help them to negotiate a new set of rules for the collection of NTFPs in the park area by poor households. Refinement of modeling of the effects of fruit gathering on the population of *Arenga pinnata* palm is still needed.
- This is planned to be done following the termination of the doctoral studies of the site coordinator with funding provided by Chulalongkorn University.

Each row of the table above is an impact pathway describing how the project contributed to outcomes in a particular actor or actors.

Which of these impact pathways were unexpected (compared to expectations at the beginning of the project?)

- No unexpected outcome observed in this (shorter) case study.

Why were they unexpected? How was the project able to take advantage of them?

What would you do differently next time to better achieve outcomes (i.e. changes in stakeholder knowledge, attitudes, skills and practice)?

Better mobilization of the park officers to design an agreement on new rules to access NTFPs in the boundaries of the park. But this needed to wait for the nomination of a new local Chief of the park in late 2009.

Doi Tiew site, Tha Wang Pha District, Nan Province, Northern Thailand

Actor or actors who have changed at least partly due to project activities	What is their change in practice? I.e., what are they now doing differently?	What are the changes in knowledge, attitude and skills that helped bring this change about?	What were the project strategies that contributed to the change? What research outputs were involved (if any)?	Please quantify the change(s) as far as possible
Doi Tiew herders who participated in PN25 activities	<ul style="list-style-type: none"> - Change in the importance of the cattle rearing sub-system on their farms (for part of the participating farmers) - Experiment with artificial "ruzi" pastures to be less dependent on natural grasslands along the Nanthaburi National Park (NNP) and areas being reforested by RFD foresters to protect headwaters 	<ul style="list-style-type: none"> - Understanding of land use & vegetation dynamics in grassland areas as affected by reforestation and cattle rearing - Improved communication with foresters - Better understanding of the need for change of their cattle rearing practices for this activity to survive in the future - Identification of a promising technological innovation 	<ul style="list-style-type: none"> - Sensitizing and interactive simulation exercises to improve the communication between herders, RFD foresters and park rangers - Tailoring of simulation tool to fit herders' and foresters' interest - Ex ante assessment of the effects of artificial pastures on land use and cattle rearing - Herder to herder training with simulator 	In depth: 10 herders in the village, more superficially: the whole set of cattle rearing farmers in the village
Representatives of government agencies: foresters from the RFD, rangers from Nanthaburi National Park (NNP), and the District livestock officer	<ul style="list-style-type: none"> - Allocated a 10 ha plot of land for a joint experiment with herders on artificial pastures - Provide "ruzi" seeds to establish and artificial pasture 	<ul style="list-style-type: none"> - Better understand the effects of cattle rearing on vegetation dynamics - Learnt how to use simulation workshops to facilitate dialogue with the herders 	<ul style="list-style-type: none"> - Involved the reforestation unit first, and the NNP rangers in a second stage only (because of their open conflict with the herders) in the ComMod process 	Several officers from each of these 3 agencies

Of the changes listed above, which have the greatest potential to be adopted and have impact? What might the potential be on the ultimate beneficiaries?

- Adoption of artificial pastures by the local herders who wish to continue to rear cattle in this catchment. This would lessen the pressure on natural grassland and facilitate the reforestation of the headwater areas.
- More households would be able to continue to farm in the area and would be less vulnerable to market price fluctuations by combining crop and animal productions.

What still needs to be done to achieve this potential? Are measures in place (e.g., a new project, on-going commitments) to achieve this potential? Please describe what will happen when the project ends

- Further support to the local stakeholders is needed to ensure the proper installation of the artificial pasture experiment in 2010.
- This is planned to be done following the return to this site of the coordinator who just graduated, with financial support provided by Chulalongkorn University.

Each row of the table above is an impact pathway describing how the project contributed to outcomes in a particular actor or actors. Which of these impact pathways were unexpected (compared to expectations at the beginning of the project?)

- The rapid move towards a collective action plan was unexpected because of the rather severe conflicting situation at initiation of this process.

Why were they unexpected? How was the project able to take advantage of them?

- Because of the Hmong herders reputation for adopting rigid stance in negotiations.
- The project capitalized on this positive outcome by accelerating the rhythm of ComMod activities up to the finalization of a concrete collective action plan.

What would you do differently next time to better achieve outcomes (i.e. changes in stakeholder knowledge, attitudes, skills and practice)?

Better take into account the farmers' cropping calendar and availability to attend field workshops to avoid conflicting dates.

Lingmteychu site, Punakha District, Central Western Bhutan

Actor or actors who have changed at least partly due to project activities	What is their change in practice? I.e., what are they now doing differently?	What are the changes in knowledge, attitude and skills that helped bring this change about?	What were the project strategies that contributed to the change? What research outputs were involved (if any)?	Please quantify the change(s) as far as possible
The farmers from 7 villages who participated in PN25 activities	<ul style="list-style-type: none"> - Irrigation water sharing - Collective management of water resources - Joining the new watershed management committee 	Understanding of the water sharing problems together and solving it collectively	<ul style="list-style-type: none"> - Putting actors in situation through interactive simulation exercise - Trainings - Exposure visits 	21 farmers and village representatives from 7 villages in this catchment
Downstream villages who participated in PN25	Expression of disagreement			2 villages
Extensionists [technology & information delivery; livestock; forestry agents]	<ul style="list-style-type: none"> - Engagement of stakeholders in NRM activities - Use of consultative process - Facilitator's role 	Skill of using RPG as mediation tool	<ul style="list-style-type: none"> - Facilitation - Learning by doing [implementation of ComMod activities] - Training of a local facilitator 	2.
Administrators [district officers]	Participation and support in the collective management of resources	Openness to consultative process	Include them in the processes	3 district officers

Of the changes listed above, which have the greatest potential to be adopted and have impact? What might the potential be on the ultimate beneficiaries?

Water sharing and management through local management committee that promotes equitable access to water.

(1) What still needs to be done to achieve this potential? (2) Are measures in place (e.g., a new project, on-going commitments) to achieve this potential? (3) Please describe what will happen when the project ends.

(1) Mainstreaming the approach and process.

(2) Yes – water policy.

(3) Strong support from government (Community-based NRM policy).

Each row of the table above is an impact pathway describing how the project contributed to outcomes in a particular actor or actors.
Which of these impact pathways were unexpected (compared to expectations at the beginning of the project?)

Triggering conflict in down-stream communities (Matalangchu and Omtékha)

Why were they unexpected? How was the project able to take advantage of them?

Management committee was expected to resolve through consultation. Not considered yet.

What would you do differently next time to better achieve outcomes (i.e. changes in stakeholder knowledge, attitudes, skills and practice)?

- Engage local administrators from the beginning.

Kengkhar site, Mongar District, Eastern Bhutan

Actor or actors who have changed at least partly due to project activities	What is their change in practice? I.e., what are they now doing differently?	What are the changes in knowledge, attitude and skills that helped bring this change about?	What were the project strategies that contributed to the change? What research outputs were involved (if any)?	Please quantify the change(s) as far as possible
Farmers who participated in PN25	Sharing water by networking of tanks	<ul style="list-style-type: none"> - Collective management - Using proper collection storage ensures quality water - Excess water shared with lower community 	<ul style="list-style-type: none"> - Putting actors in situation through interactive simulation exercise - Community field visit 	All the village households
Agriculture Extension	Using the network of water-users in managing water	Water collection can help irrigating vegetable crops	Training, facilitation & monitoring and evaluation	2 officers
School and Basic Health Unit	Roof water collection and diverting to community reservoir	Provision of adequate clean water can help promoting hygiene	Engage them in consultative process	

Of the changes listed above, which have the greatest potential to be adopted and have impact? What might the potential be on the ultimate beneficiaries?

Sharing water by tank networks reduces time for water collection and assures clean water for longer period.

(1)What still needs to be done to achieve this potential? (2)Are measures in place (e.g., a new project, on-going commitments) to achieve this potential? (3) Please describe what will happen when the project ends.

- (1) Supplementary water sources or community reservoirs.
- (2) Yes – government committed to explore the potentials.
- (3) Community management of scheme.

Each row of the table above is an impact pathway describing how the project contributed to outcomes in a particular actor or actors. Which of these impact pathways were unexpected (compared to expectations at the beginning of the project?)

Engagement of school and health office in supporting to address the issue.

Why were they unexpected? How was the project able to take advantage of them?

They did not control springs as they had independent water supply systems.
We engaged them in the campaign on clean water for hygienic way of living and availability of structures for roof water harvesting.

What would you do differently next time to better achieve outcomes (i.e. changes in stakeholder knowledge, attitudes, skills and practice)?

Wider participants and dissemination to other areas. It will be easier now that this case study is considered as a pilot one at the national level.

Radi site, Trashigang District, Eastern Bhutan

Actor or actors who have changed at least partly due to project activities	What is their change in practice? I.e., what are they now doing differently?	What are the changes in knowledge, attitude and skills that helped bring this change about?	What were the project strategies that contributed to the change? What research outputs were involved (if any)?	Please quantify the change(s) as far as possible
Herders who participated in PN25	<ul style="list-style-type: none"> - Implementing of rotational grazing techniques - Stall feeding (for downstream village) - No more encroachment beyond their designated areas - 3 communities engage in the greening effort (> 1000 acres) identified for reforestation 	Discovering of fencing rotational grazing techniques	<ul style="list-style-type: none"> - Putting actors in situation through interactive simulation exercise - Trainings - Exposure visits 	6 Radips and 6 Merak herders
Forester and Agriculturist	Jointly engaged people in reforestation and grazing land management	Concept of integrated RM	Awareness building, training, and learning by doing	2 local officers
Administrator	<ul style="list-style-type: none"> - Used technical options rather than administrative/legal means - Hazelnut plantation being finalized for Green Belt area 	Openness to consultative process using technical options	Participatory consultative process	

Of the changes listed above, which have the greatest potential to be adopted and have impact? What might the potential be on the ultimate beneficiaries?

Fencing and rotational grazing as management of grazing land can lead to better land management. Sustainable watershed management.

What still needs to be done to achieve this potential? Are measures in place (e.g., a new project, on-going commitments) to achieve this potential? Describe what will happen when the project ends.

Implementation of rotational grazing and Plantation, Yes- Major plantation project is being finalized.

Each row of the table above is an impact pathway describing how the project contributed to outcomes in a particular actor or actors.

Which of these impact pathways were unexpected (compared to expectations at the beginning of the project?)

Reforestation of the upper catchment.

Why were they unexpected? How was the project able to take advantage of them?

It was not included in the process. It would keep the two communities separated by the green belt and can better manage their grazing land, while they collectively benefit from the plantation.

What would you do differently next time to better achieve outcomes (i.e. changes in stakeholder knowledge, attitudes, skills and practice)?

Engage local administrators from the very beginning.

Bibliography CPWF Project Report

The ComMod processes implemented at nine diverse sites in three countries and in different agro-ecological zones and socio-cultural contexts dealing with different water management problems led to a variety of key outcomes depending on the process dynamics. We grouped them in the following three categories:

- PN25 raised the capacity of local stakeholders and strengthened local institutions to tackle common NRM issues in diverse contexts,
- PN25 led to the improvement of communication and trust among multiple stakeholders through collective learning facilitated by interactive simulations,
- The implementation of Companion modeling processes contributed to the mediation of water use conflicts through the design and use of families of models with stakeholders.

Practically, in Bac Lieu province of the Mekong delta, Vietnam, the process led to the adjustment of water quality requirements in the canals allowing farmers to grow more rice and include other components in their farming systems rather than only shrimp monoculture, to minimize the economic risk. The local impact pathway let us think that similar adjustment of water requirements could occur in other neighboring provinces, facing the same problem of coordination of the management of the salinity control system leading to more land use change by farmers.

In the rainfed lowland rice (RLR) ecosystem of Ubon Ratchathani, the co-design of a simulator representing the interactions between water, RLR production and labor migrations improved very significantly the participating farmers' communication skills and led to new demands. They are able to present their ABM simulator to M.Sc. students and faculty at the local University and this illustrates a major change in the relationships between farmers and researchers due to ComMod activities. They now request a new project to look at the diversification out of rice and the product marketing issues. In the upland areas of Northern Thailand, improved cropping patterns for more adaptive farm management and resource-sharing were observed at the Maehae site making local farms less vulnerable to market price and rainfall fluctuations. The village committee leaders need to keep enforcing the implementation of the agree-upon resource use practices and to institutionalize the organization of interactive workshops to foster collective thinking and exchange of practices. While at the nearby Mae Salaep site, the village leaders are eager to look for an alternative donor following the rejection by the sub-district administration of the water storage and distribution project designed by the villagers during the process because of a conflict of interest. Also in the Northern Thailand highlands, an agreement between villagers and foresters for the joint management of resources along the local forest – farm land interface was formally signed by all parties involved in the Nam Haen catchment of Nan province, and this could secure a continuous access to NTFPs by the most vulnerable farming households based on a new set of agreed upon rules. At the adjacent Doi Tiew site, the adoption of artificial pastures by the local herders who wish to continue to rear cattle in this catchment could lessen the pressure on natural grasslands and facilitate the reforestation of the headwater areas. More households would be able to continue to farm in the area and would be less vulnerable to market price fluctuations thanks to combinations of crop and animal productions.

In Lingmuteychu catchment of Western Central Bhutan, water sharing and management through the establishment of a local management committee that promotes equitable access to water was achieved. But the initial success re-ignited an old conflict in downstream communities to be resolved by the Management committee through consultation. While at the Kengkhar site of Eastern Bhutan, sharing water by a network of tanks reduces time and energy for water collection, particularly by women and children, and assures clean water for longer period. The impact pathway benefits from the engagement of school and health offices in supporting further improvement of the water supply system through roof water harvesting. This was not expected initially as they do not control springs and have independent water supply systems. It will now be easier to disseminate this experience to

other areas as this case study is considered as a pilot one at the national level. In the same region, fencing and rotational grazing were identified by the local stakeholders to better manage the Sheytimi grazing lands at Radi site, while a major plantation project is being finalized to rehabilitate the already degraded parts of these over-grazed highlands. Again, the reforestation of the upper catchment was not expected as it was not included in the question examined in the ComMod process. But it would keep the two communities of herders in conflict and their respective grass lands separated by a green belt, while they will collectively benefit from the plantation.

PN25 had a strong training component made of complementary activities. Six site coordinators (3 Thais and one Bhutanese, French and Vietnamese each) undertook doctoral studies during the project, two of them under a joint-degree program between Paris Ouest Nanterre La Défense University, France (Human, economic and regional geography doctoral programme) and Chulalongkorn University in Bangkok, Thailand (Agro-technology PhD program). Three of them graduated at Paris Ouest University in France with the unanimous congratulations of the jury and another one also obtained the top mark at Lyon University, France. A Thai master student supported by the project graduated in "Integrated farming" at the Faculty of Agriculture, Ubon Rajathanee University, Thailand in February 2009 and a Bhutanese collaborator was granted a diploma degree in "integrated watershed management" from Kasetsart University in Bangkok in May 2009. We observed that in all cases, the doctoral research implemented by the students required more time than planned due to the difficulty of the subject (requiring system thinking, a critical assessment of own work, an array of skills from group facilitation to the command of a computer modelling and simulation platform). But at the end of the project, all the Thai and Vietnamese PhD students have graduated and are back in their respective Faculties and Universities where they use their new knowledge in teaching appropriate master programmes.

A small regional network of users was created during the project and is linked to two international ones: the ComMod network gathering people interested by this approach, and the CORMAS list of users of this MAS simulation platform. The innovative methodology and its key tools is currently being transferred to more interested people through local institutions of higher education where several of PN25 site coordinators are teaching. At the end of the project, a regional training course on the approach was designed and held at Chulalongkorn University in Bangkok during which the project PhD candidates were able to make presentations of their results (see below the list of PN25 training materials).

3. International Public Goods

3.1 Tools and Methodology

Apart from the new knowledge (on stakeholders' perceptions of water dynamics, water management systems, etc.) generated through the research at the nine different sites, the project produced two important international public goods:

- A refined and field-tested version of the ComMod approach for collective management of water at the catchment scale (see at: <http://www.commod.org/en> where a lot of user-friendly information is available), and
- A set of freely available modelling and simulation tools that could be fine tuned to examine similar water management issues at other sites. All of them were implemented under the CORMAS simulation platform (available at <http://cormas.cirad.fr/indexeng.htm> where one can find tutorials for self-training, descriptions of the ABMs developed according to the Overview - Design concepts - Details - ODD- standard protocol for documenting such models and their code). The descriptions of many RPGs produced by PN25 are available as Powerpoint presentations. A template of the logbook designed for monitoring ComMod processes is also available as well as examples from several sites.

Bibliography **CPWF Project Report**

Similar ComMod processes and simulation tools have also been applied at some 40 different sites in African, Asian, European and Pacific Ocean countries. 27 of these case studies (including 5 from PN25) were assessed under a special project during 2007-2009 and the results were published in Etienne 2010 to further disseminate the lessons learnt from these early experiments with ComMod.

The PN25 website (see at <http://www.cpwf25.sc.chula.ac.th>) is another tool used to make PN25 outputs (news, training materials, case studies, library of models with their respective ODD documents and the computer code, RPGs, logbooks of M&E, publications – some are available in national languages, video clips, photos, etc.) available to interested people.

3.2 Project Insights

Training on ComMod methodology illustrated by PN25 case studies is being offered in various places (sometimes in national language) as reported in the previous section on findings under objective 2.

Linkages with other CPWF basins and related projects (Echel Eau Project) were maintained throughout the project. The last regional training event held in Bangkok in May 2009 allowed to broaden the network of contacts and to initiate a new project building on PN25 to be implemented in the Volta basin during the Phase 2 of CPWF.

International networking of the practitioners of the ComMod approach and tools is functioning thanks to two electronic lists dedicated to ComMod and Cormas respectively.

4. Partnership Achievements

Close relationships among PN25 partners (and their local collaborating agencies at each site) were developed thanks to the organization of five technical workshops associated with cross site visits, the joint organization of training courses in Bhutan (January 2006 and December 2007) and Thailand (January and May 2009), the preparation of conference papers and journal articles, and formal & informal joint academic activities among PN25 PhD students.

New linkages between IWMI – ARIs – NARS of the three countries involved were established and broader networking achieved through PN25 participation in the first and second International Forum on Water and Food (IFWF) in 2006 and 2008 in Vientiane, Laos and Addis Ababa, Ethiopia, respectively.

The continuous improvement of the PN25 website also played a role in networking and the integration of the project in the global ComMod network of practitioners. PN25 site coordinator at the Faculty of Science, Chulalongkorn University has accepted to continue to update and maintain the PN25 website hosted on a CU server in the foreseeable future.

In 2009, the site coordinators in Thailand organized themselves to help a new node of the Thai network to get started at the Faculty of Natural Resources of Prince of Songkla University (FNR-PSU), while trainees from 12 different countries attended the final training event held at Chulalongkorn University in May 2009. Some links with other CPWF projects in the Mekong basin were maintained and led to joint publications, and the close association of PN25 with the Echel Eau Project played a crucial role in training activities, particularly in the last year of the project. PN25 also provided opportunities to access funding from UNDP & DANIDA for farmers groups at two sites in Bhutan.

5. Recommendations

- *In the field of research*: this project showed that working as a network, sharing a common methodology, tools, and experiences grounded in local organizations has been very productive. It also underlines the need to adapt participatory modelling processes to the specificities of local situations and to care for people who are interested for better impact. Good participatory modelling research requires a flexible time line, and further work is still needed to make the computer tools to build models more user-friendly. Now that a small regional network of CORMAS users has been established, it is also proposed that members with good programming skills could support other members in developing their computer simulation tools.

- *For extension*: PN25 showed the importance of learning by doing training activities for extension agents who are very important partners in such processes. Specific efforts are needed to make them (and researchers) true facilitators of such processes and, because of their intensive interactions with local actors, it is essential to involve them in on-site monitoring and evaluation of participatory modelling processes.

- *Regarding policy*: more time should have been allocated at the beginning the project to sensitize administrators and policy makers to better involve them in participatory processes at a later stage, taking into account the fact that they move frequently from a position to another one making difficult the assessment of the right time to engage them for lasting impact. It is also essential to take into account the way dialogue and action with policy makers works, often not according to gradual steps from a given organization level to the next one. This collaborative modeling approach works better when a supporting community-based NRM policy is in place.

- *About institutions*: PN25 achievements show the importance of institutional support for lasting outcomes & impact of such collaborative modelling processes. Very tangible impact was observed where a supporting policy and institutional framework was available allowing the exciting creative design of local institutions for collective management of water. But in any context, the management of social inequity, power relations & linkages with institutions at higher levels of organization are crucial for the success of such processes, especially when up-scaling them.

- *Regarding CPWF*: the PN25 author team thanks the managing team for the flexibility in timing of implementation granted as it is much needed in this area of research. The two IFWF forums were also highlights along the project life span.

6. Publications

6.1. List of PN25 publications

So far, 16 peer-reviewed journal articles, 7 book chapters, 38 conference papers and 9 posters have been published by this project. More journal articles are still under preparation following the recent termination of doctoral studies by several site coordinators. All PN25 publications and training materials on the ComMod approach and its specific tools are deposited at <http://www.cpwf25.sc.chula.ac.th> .

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- Barreteau O. *et al.* Contingent participatory modelling and trust building: Comparative analysis of PN25 ComMod case studies on water management at the catchment scale.
- Cernesson F., Hoanh C.T. *et al.* Representation of biophysical processes in PN25 ComMod models on water management at the catchment scale.
- Gurung T.R. *et al.* Effects & impact of ComMod processes: Comparative analysis of PN25 case studies.
- Le Page C. *et al.* Diversity and adaptation in ComMod processes: Comparative analysis of PN25 ComMod case studies on water management.

6.3. List of PN25 training materials

The presentations given during the International Training Course on Companion Modelling for Integrated Renewable Resource Management, on 11-22 May 2009 at the Faculty of Science, Chulalongkorn University, Bangkok, Thailand were voice-recorded. The corresponding slideshows can be listened to on the project website at: <http://www.cpwf25.sc.chula.ac.th>

Plenary lectures

-  Introduction to ComMod training [G. Trébuil; 15 slides]
-  Companion Modelling in the field of modelling for INRM [G. Trébuil; 29 slides]
-  Introduction to Modelling [C. Le Page; 30 slides]
-  Companion modeling for Resilient and Adaptive Management of Social-Ecosystems: history, principles, tools & effects [G. Trébuil; 40 slides]
-  UML: formal diagrams to specify conceptual models [C. Le Page; 35 slides]
-  UML: How to use the MagicDraw software? [W. Naivinit; movie only]
-  Initiation and facilitation of a ComMod process [G. Trébuil; 19 slides]
-  PARADI: a methodology for the collaborative modelling of socio-ecosystems [C. Le Page; 21 slides]
-  Objectives, characteristics and construction of ComMod Role-Playing Games (RPG) [C. Le Page; 35 slides]
-  Introduction to Agent-Based Models used in ComMod for IRRM [C. Le Page; 14 slides]
-  Associations and combinations of ABM and RPG in ComMod [C. Le Page; 16 slides]
-  Smalltalk in a nutshell [C. Le Page; 27 slides]

- ✚ Cormas (**C**ommon-pool **R**esources and **M**ulti-**A**gent **S**ystems): a simulation environment dedicated to the creation of agent-based models [C. Le Page; 28 slides]
- ✚ Monitoring and evaluation of a ComMod process: principles, methodology, tools & results [G. Trébuil; 46 slides]
- ✚ ComMod for IRRM: lessons, hot topics and future perspectives [G. Trébuil; 33 slides]

Case studies

- ✚ [Lingmutyechu] Conflict resolution & institutional building in a watershed of West-Central Bhutan [T. Raj Gurung; 48 slides (pdf only)]
- ✚ [Nam Haen] Mediation of a conflict between two farming communities and a national park in Northern Thailand [P. Dumrongrojwatthana; 44 slides]
- ✚ [Bac Lieu] Salinity patterns and integrated rice-shrimp farming in Bac Lieu Province, Mekong Delta, Vietnam [Le Canh Dung; 54 slides]
- ✚ [Ban Mak Mai] Analysis of land/water use and labour migration interactions in Lower Northeast Thailand [W. Naivinit; 87 slides]
- ✚ [Doi Tiew] Mediation of a land use conflict between herders and foresters in Northern Thailand [P. Dumrongrojwatthana; 58 slides]
- ✚ [Mae Hae] Land and water management in a Northern Thailand watershed [P. Promburom; 64 slides (pdf only)]
- ✚ [Mae Salaep] Adaptive land & water management in Mae Salaep, Northern Thailand [G. Trébuil; 86 slides]

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Appendices

Appendix A. Description of the collaborative modelling processes implemented at each of PN25 nine sites.

The modelling processes are described by referring to the twelve steps of Companion Modelling approach (Etienne and Bousquet, 2009). For each step, the participants involved (local stakeholders, scientists or decision makers) and the tools developed or used are specified.

Definition of the contents of each step in a ComMod process

Step	Short name	Name	Definition & comments
1	Sensitizing	Sensitizing activities	Sensitizing activities: introduction of the ComMod approach to the key stakeholders requesting to look into a given development-oriented question; assessment of its suitability and of the feasibility to use it in the local context (included training session); introduction of the case issue
2	Key question	Definition of the key question	Problem identification & definition of the key question to be examined: done by the process leaders and, sometimes, other stakeholders too
3	Data gathering	Collection of information related to issue	Inventory of relevant scientific, expert, and indigenous relevant knowledge available through literature review & complementary diagnostic surveys to fill the gaps
4	Eliciting knowledge	Eliciting knowledge for modeling	Knowledge elicitation for modeling via surveys and interviews
5	Conceptual model	Conceptual model design	Design of the conceptual model (need to specify if it is carried out with the concerned stakeholders, in lab., etc.)
6	Implementation	Model implementation	Choice of the suitable tool (computer-based or not) and model implementation
7	Verification & validation	Model verification, validation and calibration	Model verification, calibration and validation (need to specify if it is carried out with the concerned stakeholders, in the lab., etc.)
8	Scenarios	Identification and definition of scenarios	Identification and definition of scenarios to be simulated with local stakeholders
9	Simulations	Exploratory simulations	Exploratory simulations of the selected scenarios with the stakeholders
10	Dissemination	Dissemination of outputs	Dissemination of the process outputs to stakeholders who did not participate in the ComMod activities so far
11	Monitoring & evaluation	Monitoring-evaluation of the effects of the ComMod process on participants	Monitoring & evaluation of the effects of the ComMod process on the participants (change in awareness, knowledge, communication, behavior, decision-making, practices, etc.) and impacts (change in the context, etc.)
12	Training	Training of stakeholders	Training of stakeholders on using the ComMod approach and its tools produced during the collaborative modeling process

The following tables describe the ComMod processes implemented at each of the project sites.

Bhutan – Lingmteychu site in Punakha District

[illegible]

Legend:

- a: training
- b: trip to Bhutan
- c: preliminary diagnosis
- d: first role-playing game (2 villages)
- e: first agent-based model (2 villages)
- f: simulations in the laboratory
- g: presentation
- h: monitoring by local facilitator stationed at the research site
- i: second role-playing game (7 villages)
- k: second agent-based model (7 village game)
- m: presentation to the all community
- n: AKB post-graduate diploma
- o: third & final agent-based model (7 village)

Bhutan – Radi site in Trashigang District

	Radi	2005												2006												2007															
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12				
1	Sensitizing										a			d																											
2	Key question										b																														
3	Data gathering											c		e																											
4	Eliciting knowledge																																								
5	Conceptual model													f	g																										
6	Implementation														m																										
7	Verification & Validation															m																									
8	Scenarios														m																						k				
9	Simulations																																								
10	Dissemination																																								
11	Monitoring & Evaluation														n														i			j									
12	Training													h																											

Legend:

a: discussion with researchers about ComMod - TRG

b: TRG

c: TRG and LS

d: introduction to researchers

e: LS in the field

f: trainees at College of Natural Resources (CNR), Royal University of Bhutan (RUB)

g: farmers update the design

h: 1 week training at CNR-RUB

i: JRQ, GT, TRG

j: TRG, PBC, LD

k: CLP and TRG

l: CLP, JQ - Cormas platform and monitoring & evaluation

m: computer-assisted role-playing game

n: on-site and external monitoring and evaluation

Buthan – Kengkhar site in Mongar District

	Kengkhar	2007												2008												2009												2010																	
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12						
1	Sensitizing											b																																											
2	Key question	a																																																					
3	Data gathering							c																																															
4	Eliciting knowledge																																																						
5	Conceptual model																																																						
6	Implementation																																																						
7	Verification & Validation																																																						
8	Scenarios																																																						
9	Simulations																																																						
10	Dissemination																																																						
11	Monitoring & Evaluation												f																																										
12	Training																																																						

Legend:

a: TRG

b: discussion with collaborators at the site

c: preliminary diagnosis

d: role-playing game

e: new staff recruited

f: on-site monitoring with local facilitator stationed at the research site

g: all water users

h: training in Bangkok

k: first agent-based model (replaying the game): TRG+CLP

o: second agent-based model (network of water tanks): TRG+CLP

Thailand – Mae Hae site in Chiang Mai Province

[illegible]

Legend:

- a: preliminary diagnosis & use of sensitizing tools
- b: preliminary diagnosis
- c: first role-playing game
- d: second role-playing game
- e: first agent-based model
- f: third role-playing game
- g: fourth role-playing game
- h: role-playing game, observation of village network
- i: equal water sharing suggested during the gaming session
- j: second agent-based model
- k: third agent-based model
- p: Panomsak Promburom's PhD defense

Thailand – Mae Saelep site in Mae Fah Luang District of Chiang Rai Province

[illegible]

Legend:

a: first role-playing game (RPG1) based on the initial ABM linked to GIS

b: first agent-based model (ABM1, autonomous simulator) implemented during the workshop, added to RPG1 to test rapidly various scenarios, (on longer term)

c: simulation with stakeholders: 12 players (farmers) & 2 local development agents as co-organizers

d: conclusion of the field workshop

e: RPG2 & ABM2 (another autonomous simulator)

f: simulations with stakeholders: 12 players (farmers) & 2 local development agents as co-organizers

g: RPG3 & ABM3 (running controled simulations)

h: simulations with stakeholders: 12 players (farmers), 1 local development agents as co-organizer, 1 sub-district administrator (TAO)

i: simulations with stakeholders in smaller and more socially homogeneous groups of farmers: 3 groups of 4 players each

j: individual interviews with the participants in the process

k: Cécile Barnaud's PhD defense

Thailand – Doi Tiew site in Tha Wang Pha District of Nan Province

	Doi Tiew	2007												2008												2009																		
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5		
1	Sensitizing																																											
2	Key question																																											
3	Data gathering																																											
4	Eliciting knowledge																																											
5	Conceptual model																																											
6	Implementation																																											
7	Verification & Validation																																											
8	Scenarios																																											
9	Simulations																																											
10	Dissemination																																											
11	Monitoring & Evaluation																																											
12	Training																																											

Legend:

a: computer-assisted role-playing game (cRPG)

b: testing exercises with stakeholders (4 foresters from the reforestation unit & 5 herders)

c: testing exercises with stakeholders (2 foresters from the reforestation unit, 5 rangers from the national park)

d: simulations with local stakeholders using cRPG-V1 (3 foresters from the reforestation unit & 16 herders)

e: addition of scenarios as requested by the players in the first set of RPG-based sessions

f: testing of additional scenarios

g: simulations with local stakeholders using cRPG-V2 (12 foresters from the reforestation unit, 3 rangers from the national park, 5 herders & 1 observer from the Livestock Development Department)

h: simulations with local stakeholders using cRPG-V3 (9 herders, including 5 newcomers)

i: complementary simulations in the laboratory

j: evaluation through individual interviews conducted by the researcher & process designer

k: agent-based model

p: Pongchai Dumrongrojwattana's PhD defense

Thailand – Lam Dome Yai site in Det Udom District of Ubon Ratchathani Province

LamDomeYai	2004												2005												2006												2007											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Sensitizing																																																
Key question																																																
Data gathering																																																
Eliciting knowledge																																																
Conceptual model																																																
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Verification & Validation																																																
Scenarios																																																
Simulations																																																
Dissemination																																																
Monitoring & Evaluation																																																
Training																																																

Legend:

a: first role-playing game

b: second role-playing game and first agent-based model

c: second agent-based model and third role-playing game

d: third role-playing game

e: second agent-based model

f: third agent-based model

g: third agent-based model fine tuned (BMM model)

h: participatory simulations with a sample of participating farmers; meeting with PN25 research team

i: simulations with BMM model in the laboratory

j: participating farmers seminar at the Faculty of agriculture, UBU

m: Manitchara Thongnoi's M.Sc. defense

p: Warong Naivinit's PhD defense

Viet Nam – Bac Lieu site in the Mekong Delta

	BacLieu	2005		2006												2007												2008																		
		11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3				
1	Sensitizing	x							a																																					
2	Key question																																													
3	Data gathering																																													
4	Eliciting knowledge																																													
5	Conceptual model																																													
6	Implementation																																													
7	Verification & Validation																																													
8	Scenarios																																													
9	Simulations																																													
10	Dissemination																																													
11	Monitoring & Evaluation																																													
12	Training																																													

x: start of PhD research study

a: preliminary diagnosis : 12-14 July, group meetings at Phong Thanh, Ninh Thanh Loi & Vinc Loic villages

b: first role-playing game at Phong Thanh with 24 players (21 farmers, 2 hamlet officers & 1 village officer) on 14-15 August; at Ninh Thanh Loi with 8 players (7 farmers & 1 hamlet officer) on 24-45 August; and at Vinc Loic with 10 players (8 farmers, 1 hamlet officer & 1 village officer) with support from 14 assistants

c: second role-playing game on 17-18 July with 17 players (12 farmers, 2 village officers, 2 district officers & 1 provincial officer)

d: agent-based model

e: workshop with 9 farmers on 25-26 August 2008

f: simulations with stakeholders on 27 February 2009 during a workshop with 6 farmers, 2 village officers, 2 district officers & 2 provincial officers

g: complementary simulations in the laboratory

h: Le Canh Dung's PhD defense

Appendix B: Training Course on Companion Modelling for Integrated Management**(ComMod for IRRM)**

11-22 May 2009 at Faculty of Science, Chulalongkorn University, Bangkok, Thailand

Schedule

Date	Time		
Monday 11 May 2009	Morning	8h30-9h00	Registration
		9h00-10h00	Opening, introduction of participants & Overview of the course
		10h00-10h30	Break
		10h30-12h00	Companion Modelling in the field of modelling for INRM
	Afternoon	13h30-15h30	Gaming session Rehab
		15h30-16h00	Break
		16h00-17h00	Plenary debriefing on the gaming session
Tuesday 12 May 2009	Morning	9h00-10h30	Introduction to companion modelling: principles, tools & effects
		10h30-11h00	Break
		11h00-12h30	[Lingmuteychu] Conflict resolution & institutional building in a w
	Afternoon	13h30-15h00	UML: formalized diagrams to specify conceptual models
		15h00-15h30	Break
		15h30-17h00	Group work on UML
Wednesday 13 May 2009	Morning	9h00-10h30	The initiation and facilitation of a ComMod process
		10h30-11h00	Break
		11h00-12h30	[Nam Haen] Mediation of a conflict between two farming commu
		13h30-15h00	PARDI: a methodology for the collaborative modelling of socio-e
		15h00-15h30	Break
		15h30-16h00	Presentation of group work on managing water in a Mekong Bas
Thursday 14 May 2009	Morning	15h30-17h00	Group work on PARDI
		9h00-10h30	Presentation of group work
		10h30-11h00	Break
	Afternoon	11h00-12h30	[Bac Lieu] Salinity patterns and integrated rice-shrimp farming i
		13h30-15h00	Objectives, characteristics and construction of ComMod Role-Pla
		15h00-15h30	Break
Friday 15 May 2009	Morning	15h30-17h00	Group work on designing a prototype RPG (1)
		09h00-10h30	Group work on designing a RPG (2)
		10h30-11h00	Break
	Afternoon	11h00-12h30	Presentation of group work
		13h30-15h00	Introduction to Agent-Based Models used in ComMod for IRRM
		15h00-15h30	Break
Saturday 16 May 2009	Whole day	15h30-17h00	[Don Hoi Lord] Razor Clam Management in the Don Hoi Lord coa
		8h00-20h30	Field trip to Don Hoi Lord research site in Samut Songkram Prov
Monday	Morning	9h00-10h30	Associations and combinations of ABM and RPG in ComMod

18 May 2009		10h30-11h00	Break
		11h00-12h30	[Ban Mak Mai] Analysis of land/water use and labour migration i
	Afternoon	13h30-15h00	Presentation of trainees' own projects related to modelling for IR
		15h00-15h30	Break
		15h30-17h00	Smalltalk in a nutshell // Trainees' RPG (conception)
Tuesday 19 May 2009	Morning	9h00-10h30	How to implement a concrete simulation model from a set of UM
		10h30-11h00	Break
		11h00-12h30	[Doi Tiew] Mediation of a land use conflict between herders and
	Afternoon	13h30-15h00	Implementing a cormas model from scratch (classes) // Trainees
		15h00-15h30	Break
		15h30-17h00	Implementing a cormas model from scratch (classes) // Trainees
Wednesday 20 May 2009	Morning	9h00-10h30	[Mae Hae] Land and water management in a Northern Thailand
		10h30-11h00	Break
		11h00-12h30	Trainees' RPG (gaming session)
	Afternoon	13h30-15h00	Trainees' RPG (gaming session)
		15h00-15h30	Break
		15h30-17h00	Trainees' RPG (debriefing)
Thursday 21 May 2009	Morning	9h00-10h30	From the trainees' RPG to an ABM in Cormas (retro-engineering
		10h30-11h00	Break
		11h00-12h30	From the trainees' RPG to an ABM in Cormas (implementation, e
	Afternoon	13h30-15h00	[Mae Salaep] Adaptive land & water management in Mae Salaep
		15h00-15h30	Break
		15h30-17h00	Implementing a cormas model from scratch (simulation) // Train
Friday 22 May 2009	Morning	18h30-21h00	Banquet - Farewell dinner - Tawana Ramada
		9h00-10h30	Monitoring and evaluation of a ComMod process: principles, met
		10h30-11h00	ComMod for IRRM: lessons learned so far, current hot topics and
	Afternoon	11h00-12h00	Use of modelling tools : the quest for "optimal" management sch
		12h00-12h30	Resources on ComMod: presentation of websites, electronic lists
		13h30-14h30	Course evaluation and plenary discussion Q/A session
		14h30-15h00	Break
		15h00-15h30	Closing ceremony

Modules of ComMod for IRRM Training Course

Trainer Code Topic

RPG

CLP D1.34 ReHab

Case studiesTRG D2.2 [Lingmuteychu] Conflict resolution & institutional building in a watershed of West-Central Thailand <*continuous process. Upscaling*>PD D3.2 [Nam Haen] Mediation of a conflict between two farming communities and a national park in Thailand <*Initial diagnosis, stakeholders analysis*>LCD D4.2 [Bac Lieu] Explorations of environmental and socio-economic aspects of integrated rice-swamp management in Bac Lieu Province, Mekong Delta, Vietnam <*Analysis of RPG sessions*>KW D5.2 [Don Hoi Lord] Razor Clam Management in the Don Hoi Lord coastal wetland in Central Thailand <*uses of computerized ABM and simplified RPG*>WN D6.2 [Ban Mak Mai] Analysis of land/water use and labour migration interactions in Lam Dong, Thailand <*Collaborative design and use of a computerized ABM (RPG as a tool to formalize a common representation of the system)*>PD D7.2 [Doi Tiew] Mediation of a land use conflict between herders and foresters in Northern Thailand <*share a common representation of the system*>PP D8.2 [Mae Hae] Land and water management in a Northern Thailand watershed <*Institutional analysis*>GT D9.2 [Mae Salaep] Adaptive land & water management in Mae Salaep, Northern Thailand <*Adaptive management cycles*>**Concepts, methods and tools**

CLP D1.2 Companion Modelling in the field of modelling for INRM

GT D2.1 Introduction to companion modelling: principles, tools & effects

CLP D2.3 PARADI: a methodology for the collaborative modelling of socio-ecosystems

GT D3.1 The initiation and facilitation of a ComMod process <*Demand, objectives, initial diagnosis, analysis, participants (sensitization, evolution)*>

CLP D3.3 UML: formalized diagrams to specify conceptual models

CLP D4.3 Objectives, characteristics and construction of ComMod Role-Playing Games (RPG)

CLP D5.1 Introduction to Agent-Based Models used in ComMod for IRRM

CLP D6.1 Associations and combinations of ABM and RPG in ComMod

CLP D7.1 How to implement a concrete simulation model from a set of UML diagrams: introduction

CLP D8.1 How to run, observe and analyze simulations: exploration of scenarios with Cormas

GT D9.1 Monitoring and evaluation of a ComMod process: principles, methodology, tools & results

GT D10.1 ComMod for IRRM: lessons learned so far, current hot topics and future perspectives

AT D10.2 Resources on ComMod: presentation of websites, electronic lists, key publications, etc.

Appendix C. Abstracts of PN25 publications

Journal articles:

Barnaud C., A. van Paassen, G. Trébuil, T. Promburom, and F. Bousquet. 2010. Dealing with power games in a companion modelling process: Lessons from community water management in thailand highlands. *The Journal of Agricultural Education and Extension* 16(1): 55 - 74. <http://dx.doi.org/10.1080/13892240903533152>.

Although stakeholder participation is expected to promote equitable and sustainable natural resource management, lessons from the past tell us that more careful attention needs to be paid to achieving equitable impacts. Now the question is how to address social inequities and power asymmetries. Some authors emphasize the need for more dialogue, while others prefer a critical perspective, arguing that dialogue might not be sufficient to avert the risk of a process deepening existing social inequities. This article aims to enrich this debate and question the practical implications of the critical perspective through an in-depth analysis of power games in a participatory process.

A Companion Modelling (ComMod) process was conducted in an Akha community of Northern Thailand with a critical perspective, i.e. with a concern for the less influent stakeholders. Simulation tools such as role-playing games were used to mediate a cross-cultural learning process among researchers, farmers and administrators about a local irrigation water management problem. The detailed analysis of power games in this learning and negotiation process reveals that in spite of initial power asymmetries, the poorest farmers of the community started to voice and assert their interests. This was very much due to the role of a Western researcher who put the equity issue on the public agenda and to the strategic support of a charismatic Christian leader.

We identify a set of practical facilitation methods that helped to manage power asymmetries and to level the playing field, but we also discuss the main limits of our cultural-embedded methodological choices. Acknowledging that 'the facilitators' neutrality' is an illusion, this study allows us to raise the question of their social legitimacy. We suggest that they should systematically make explicit and reflect on their cultural-ideological background and methodological hypothesis and choices and their effects on the socio-political context. This article is an original attempt to accept this challenge.

Barnaud C., F. Bousquet, and G. Trébuil. 2007. Multi-agent simulations to explore rules for rural credit in a highland farming community of Northern Thailand. *Ecological Economics* 66(4): 615-627.

Multi-agent systems (MAS) open new modelling and analysis perspectives in ecological and social sciences. An original characteristic of the companion modelling (ComMod) approach adopted in this case study is the co-construction and use of a MAS model with and for local stakeholders such as farmers and local administrators. Alternating iteratively field and modelling activities, this approach facilitates collective learning among local stakeholders and between them and the researchers. Combining the use of MAS models with role-playing games (RPG), the described experiment aimed to facilitate collective decision-making in a socially heterogeneous community of small farmers in mountainous Northern Thailand about the local rules for the allocation of rural credit to allow a more equitable and extensive process of expansion of non-erosive perennial crops in a watershed prone to erosion. This paper presents the MAS model and the results of a series of simulations exploring the ecological, social and economic effects of various rules for formal and informal credit suggested by the villagers-participants. Six scenarios considered as pertinent to further explore the participants' suggestions were defined based on different combinations among the following three variables: (i) Duration for the reimbursement of loans, (ii) Mode of allocation of formal credit among

three different types of farms, (iii) Configuration of networks of acquaintances for access to informal credit.

Drawing on this case study, we first elaborate on the potential of bottom-up models such as MAS to analyze the functioning of agricultural systems, in particular farm differentiation and rural credit dynamics. We highlight the ability of MAS to deal with interactions between social and ecological dynamics and to provide an alternative to classical economic thinking by analyzing the effects at the village level of social interactions among individuals. MAS allow us in particular to trigger an overlooked but nevertheless fundamental aspect of socioecological systems, i.e. social capital which is a determining factor when dealing with sustainability issues. The second question addressed in this paper deals with the potential and limits of MAS models to support a bottom-up (or participatory) modelling approach. This experiment suggests that the usefulness of models relies much more on the modeling process than on the model itself, because a model is usually useless if it is misunderstood by its potential users, or if it does not respond to their current preoccupations. The intuitive representation of real systems provided by MAS and their high flexibility are the two underlined characteristics favouring their appropriation by local stakeholders.

Barnaud C., G. Trébuil, P. Dumrongrojwatthana, and J. Marie. 2008. Area study prior to companion modelling to integrate multiple interests in upper watershed management of northern Thailand. *Southeast Asian Studies* 45(4). 559-585.

Ethnic minorities living in the highlands of northern Thailand have long been accused of degrading the upper watersheds of the country's major basins. In the nineties, the Thai government reinforced his environmental policies and further restricted their access to farm and forest resources. In the meanwhile, the policy framework also favoured decentralization and public participation. This contradiction resulted in an increasing number of conflicts over land-use between local communities and state agencies. This situation underlines the need for adapted participatory methodologies to facilitate the coordination of multiple stakeholders with competing interests. Companion Modelling (ComMod) is one of them. When drawing the lessons from many past participatory projects, several authors highlight their limited impact due to the lack of support at higher institutional levels. Moreover, because of a lack of attention to the local socio-political situations, the less powerful stakeholders were often left behind. This article discusses the usefulness of an area diagnostic study prior to the launch of a ComMod process to avoid such pitfalls and to facilitate genuine communication among stakeholders within and across institutional levels. The article is illustrated by a ComMod experiment conducted in Nan province and is focusing on a conflict between two Yao communities and a recently established national park. We argue that a relatively short but well-structured initial agrarian and institutional analysis to assess the various stakeholders' characteristics, perceptions of the issue to be solved, and interactions is useful to identify the constraints to an equitable outcome of a subsequent participatory process. Such an area diagnosis can also be used to tailor the ComMod process in order to mitigate these constraints. Moreover, an understanding of the initial resource management situation is necessary to be able to monitor changes and to assess the effects of the participatory process.

Barnaud C., T. Promburom, G. Trébuil, and F. Bousquet. 2007. An evolving simulation and gaming process to facilitate adaptive watershed management in mountain northern Thailand. *Simulation and Gaming Journal* (38): 398-420.

The decentralization of natural resource management provides an opportunity for communities to increase their participation in related decision making. Research should propose adapted methodologies enabling the numerous stakeholders of these complex socioecological settings to define their problems and identify agreed-on solutions. This article presents a companion modeling (ComMod) experiment combining roleplaying games and multiagent systems conducted in a community in northern Thailand to support collective learning for adaptive land management. Researchers and local stakeholders collectively built a representation of the situation and used it as a platform to explore scenarios. This ComMod process initially addressed a soil erosion problem. The participants identified the expansion of perennial crops as a promising solution but also raised the problem of the unequal ability among villagers to invest in such crops. The researchers flexibly adapted the simulation tools to the emerging matter. The authors assess the learning effects of this experiment and identify two favoring factors: the increasing participation of local stakeholders and a flexible and adaptive modeling process suited to learning, which by nature is an evolving process. But to ensure sustainable impacts for the communities, stronger links with higher institutional levels are needed.

Barnaud, C., P. Promburom, F. Bousquet, and G. Trébuil. 2006. Companion modelling to facilitate collective land management by Akha villagers in upper northern Thailand. *J. World Association of Soil Water Conservation* (1) :38-54.

In the highlands of northern Thailand, ethnic minorities are accused by lowlanders of aggravating the risk of soil erosion on steep slopes through recent land use changes. Government authorities have threatened to further restrict their access to farm land. But whether this risk is increasing or not, and how to prevent this problem are complex questions. In the recent past, an impressive amount of research efforts to control soil erosion led to limited success and highlighted the need for more integrated approaches to deal with this problem. Soil and water conservation is embedded in complex eco-socio systems, with numerous interacting ecological and social dynamics, and an increasing number of stakeholders with different interests and perceptions. Companion Modelling (ComMod) is an emerging approach designed to facilitate collective learning in such complex systems. By combining tools such as Multi-Agent Systems and Role Playing Games, it aims at developing simulation models integrating different stakeholders' perceptions to use them within the context of platforms for collective learning. A ComMod process has been tested since 2002 in an Akha village of upper northern Thailand to examine collectively the interactions between soil and water conservation, agricultural diversification, and social equity. The objective of this paper is to present the way a shared representation and understanding of the problem and its key dynamics is achieved, and how it can be used to support collective learning. It describes the concrete use of the ComMod approach with Akha villagers and illustrates how farmers' interest shifts along the learning process from agronomic concerns (soil erosion) to socioeconomic mechanisms (allocation of rural credit to invest in non-erosive perennial crops). The flexibility and adaptive characteristics of the approach are highlighted as they fit with the evolving nature of collective learning processes. The paper ends with suggestions on how to improve the ComMod process by establishing a dialogue with higher levels of organization to sustain the dynamics emerging at the village level.

Bibliography CPWF Project Report

Bousquet F., J. C. Castella, G. Trébuil, C. Barnaud, S. Boissau, and S.P. Kam. 2007. The use of multi-agent systems in a companion modeling approach for agroecosystem management in Southeast Asia. *Outlook on Agriculture* 36(1): 57-62.

This paper describes research using multi-agent systems as a companion modelling tool to address key issues related to agroecosystem management in northern Thailand and northern Vietnam. The authors illustrate an approach for the use of complex models for the accompaniment of adaptive management experiences. First, some considerations on the shifts of paradigm that underlie the research are discussed. Then two case studies are presented. The first one illustrates the iterative process of problem solving with local stakeholders, while the second emphasizes the emergence of local institutions in the context of land reforms. In both cases, the research started with an analysis of the agrarian system, which integrated multiscale biophysical and socioeconomic knowledge by means of a model. The research process then evolved towards the use of such models in participatory approaches for community-based natural resource management. Regular interactions between researchers and local stakeholders mediated by the companion modelling tools were helpful in progressing local development.

Dumrongrojwatthana, P., Le Page, C., Gajasen, N., and Trébuil, G., forthcoming. Co-constructing an agent-based model to mediate land use conflict between herders and foresters in northern Thailand. *Journal of Land Use Science*.

In conservation areas, land use conflicts occur frequently due to an increasing number of land resource managers and users. They usually have different interest, objectives and perceptions. Sharing all these a priori legitimate differences is a pre-requisite for better collective management of the land. The Companion Modelling approach is used to build a shared representation of interactions between vegetation dynamics, reforestation efforts, and livestock grazing in a forest conservation area of northern Thailand. The article focuses on the participatory modelling process that led to the co-construction of an agent-based model. Sensitizing exercises on vegetation dynamics and an agent-based simulator associated to a role-playing game were the main tools used. The social interactions and decision-making processes observed during the gaming and simulation sessions were used to construct a set of rules implemented in a subsequent autonomous agent-based model. It will be used to simulate future land management scenarios with local stakeholders.

Dung L. C., C. T. Hoanh, C. Le Page, F. Bousquet, and N. Gajasen. 2009. Facilitating dialogue between aquaculture and agriculture: lessons from role-playing games with farmers in the Mekong Delta, Vietnam. *Water Policy* 11(S1): 80-93.

During the last few years, conflicts between agriculture and aquaculture have been an important issue in the Bac Lieu province, Mekong Delta, Vietnam. A large area of rice production has been converted to shrimp or shrimp-rice based production systems that require the intake of saline water into fresh water zones that have been used for agriculture. To manage this conflict, the provincial authorities have reviewed land use plans and identified a buffer zone with a mixed land use system of shrimp-rice (rice in the rainy season and shrimp in the dry season when sluices are opened). Under the CPWF (Challenge Program on Water and Food) Project No. 25, role playing games (RPGs) were applied for analyzing the land and water management strategy of farmers in the buffer zone. The RPGs organized in three villages (Phong Thanh, Ninh Thanh Loi and Vinh Loc) indicate that due to much higher revenue earned from shrimp compared with rice, farmers are attempting numerous techniques to prolong the duration of saline water in their fields for shrimp cultivation. This strategy makes the growing of a subsequent rice crop impossible even in the rainy season, thus requiring harmonization

of water management at different levels (farm and canal systems). The results from these RPGs also indicate the need for further research on cultivation techniques for the shrimp–rice systems and on participatory methods to achieve better understanding of farmers' decisions.

Gurung, T.R., F. Bousquet, and G. Trébuil. 2006. Companion modeling, conflict resolution, and institution building: Sharing irrigation water in the Lingmutyechu watershed, Bhutan. *Ecology and Society* 11(2):36.
<http://www.ecologyandsociety.org/vol11/iss2/art36/>

We used multi-agent systems (MAS), following the companion modeling method, to facilitate water management negotiations in Bhutan. We show how this methodology helped resolve a conflict over the sharing of water resources by establishing a concrete agreement and creating an institution for collective watershed management. The conceptual model begins with a role-playing game (RPG). The stakeholders play the game, thus validating the proposed environment, the behavioral rules, and the emergent properties of the game. It is then relatively easy to translate the RPG into computerized MAS that allow different scenarios to be explored. After this first step in the MAS model, stakeholders then create an institution. A second model is developed to facilitate this process. We conclude by discussing the relationship between the models and reality, as well as the use of MAS as a mediation tool and the social process.

Naivinit, W., C. Le Page, G. Trébuil., and N. Gajaseni. 2010. Participatory agent-based modeling and simulation of rice production and labor migrations in Northeast Thailand. *Environmental Modelling and Software* 25(11): 1345-1358.

Rainfed lowland rice production in lower Northeast Thailand is a complex and adaptive farming activity. Complexity arises from interconnections between multiple and intertwined processes, affected by harsh climatic and soil conditions, cropping practices and labor migrations. Having faced a spatially heterogeneous and dynamic environment for centuries, local rice farmers are very adaptive and are used to adjusting their behavior in unpredictable climatic and economic conditions. Better understanding is needed to manage the key interactions between labor, land and water use for rice production, especially when major investments in new water infrastructure are now being considered.

Based on the principles of the iterative and evolving Companion Modeling (ComMod) approach, indigenous and academic knowledge was integrated in an Agent-Based Model (ABM) co-designed with farmers engaged in different types of farming practices over a period of three years to create a shared representation of the complex and adaptive social–agroecological system in Ban Mak Mai village, in the south of Ubon Ratchathani province.

The ABM consists of three interacting modules: Water (hydro-climatic processes), Rice, and Household. “Household” is a rule-based agent; it makes daily decisions based on its available means of production, taking into account the stage of the rice crop, and water and labor availability. Key decisions made are related to: i) rice nursery establishment, ii) rice transplanting, iii) rice harvesting, and iv) migration of household members. The spatially explicit model interface represents a virtual rainfed lowland rice environment as an archetypical toposequence made of upper to lower paddies in a mini-catchment farmed by 4 different households, and also includes water bodies and human settlements. Thanks to intensive communication, the participating farmers, made sure that the ABM adequately represents their rice farming and labor migration management practices. They found the model useful to deepen their understanding of the interrelations between labor migrations and rice production, which helped to strengthen their adaptive management ability.

Robinson D.T., D.G. Brown, D.C. Parker, et al. 2007. Comparison of empirical methods for building agent-based models in land use science. *Journal of Land Use Science* 2(1): 31-55.
<http://www.informaworld.com/smpp/content~db=all~content=a777244786~frm=titlelink>.

The use of agent-based models (ABMs) for investigating land-use science questions has been increasing dramatically over the last decade. Modelers have moved from 'proofs of existence' toy models to case-specific, multi-scaled, multi-actor, and data-intensive models of land-use and land-cover change. An international workshop, titled 'Multi-Agent Modeling and Collaborative Planning—Method2Method Workshop', was held in Bonn in 2005 in order to bring together researchers using different data collection approaches to informing agent-based models. Participants identified a typology of five approaches to empirically inform ABMs for land use science: sample surveys, participant observation, field and laboratory experiments, companion modeling, and GIS and remotely sensed data. This paper reviews these five approaches to informing ABMs, provides a corresponding case study describing the model usage of these approaches, the types of data each approach produces, the types of questions those data can answer, and an evaluation of the strengths and weaknesses of those data for use in an ABM.

Ruankaew N., C. Le Page, P. Dumrongrojwattana, C. Barnaud, N. Gajasen, A. van Paassen, and G. Trébuil. 2010. Companion modeling for integrated renewable resource management: A new collaborative approach to create common values for sustainable development. *International Journal of Sustainable Development and World Ecology* 17(1): 15-23.
<http://dx.doi.org/10.1080/13504500903481474>.

The sustainable management of renewable resources is often complicated by the diversity and dynamic nature of the ecological and socio-economic systems involved. As the dynamics and interactions of these systems are highly complex and frequently unpredictable, there is a need to opt for transdisciplinary research addressing adaptive and integrated management of renewable resources. Companion modelling (ComMod) is a multi-agent systems (MAS)-based approach relying on synergistic effects between role-playing games (RPG) and agent-based models (ABM) to facilitate collective information sharing and learning, and to improve coordination among stakeholders for negotiation and decision-making. The iterative and adaptive sequences of fieldwork with modelling activities allows the mutual and interactive participation of stakeholders during the design, implementation, calibration and validation steps of the models, as well as exploration of possible scenarios. ComMod was implemented in a study of the conflict between two ethnic communities and a newly proposed national park in Northern Thailand. Deforestation, biodiversity conservation and the livelihoods of the villagers were key issues discussed during RPG sessions with small groups of participants, and subsequently represented in an ABM simulator used with a larger audience. Consequently, the local stakeholders learned about agro-ecological and socio-economic dynamics and gained an increased awareness of these key issues. Mutual understanding was improved, and the importance of collaborative discussion, essential to negotiations and decision-making, became obvious. Finally, this Northern Thailand experience has shown that collaborative interactions mediated by ComMod were supportive of improved communication and joint learning for the adaptive and integrated sustainable management of renewable resources.

Trébuil G., B. Ekasingh, and M. Ekasingh. 2006. Agricultural commercialisation, diversification, and conservation of renewable resources in northern Thailand highlands. *Moussons* 9/10: 131-155.

The process of commercialisation-diversification in the highlands of upper northern Thailand and the accompanying dismissal of self-subsistence is documented based on the findings from seven case studies carried out in different agricultural and social situations during the past decade. The characteristics of the key driving forces powering this agrarian transition such as rapid economic growth, decrease in the share of labour employed in the agriculture, urbanization and changes in food consumption patterns, and improved communication infrastructures, are presented in the Thai context. The environmental impact of these profound agrarian transformations on the degradation of key renewable resources, particularly soil erosion, is assessed. Their socio-economic consequences on an extensive differentiation among farming households and equity issues are also discussed. Finally the authors draw several lessons from this Thai experience that illustrate the very strong adaptive capacity of small highland farmers. They could be useful in similar agro-ecological zones of neighbouring countries that are presently experiencing the same kind of agricultural transition in the Montane Mainland South East Asia ecoregion. Particularly, the article underlines the need for more holistic and integrated approaches to agricultural development and the management of renewable resources in highland agro-ecosystems to alleviate poverty while conserving the resource base.

Books and book chapters:

Barnaud C., O. Barreteau, F. Bousquet, et al. 2006. Companion modelling for resilient water management: Stakeholders' perceptions of water dynamics and collective learning at the catchment scale. In *France and the CGIAR: Delivering scientific results for agricultural development*. pp. 98-101.

A project in the Challenge Program on Water and Food uses companion modeling to deal with conflicts regarding access to water among farmers and villages in Bhutan, tensions over water use between upstream and downstream communities in northern Thailand, conflict between agricultural intensification and labor migration in lower northeast Thailand, and conflict between rice producers and shrimp growers in southern Vietnam. The technique uses various tools in a participatory way to generate a common vision of the problem among stakeholders and to examine new resource-sharing scenarios identified by them.

It is widely recognized that poor coordination among stakeholders leads to inefficient water use, economic and environmental damage, negative externalities and social conflicts. Diverse stakeholders use water resources for different purposes: agricultural uses, fishing and aquaculture, transport, tourism, drinking water, etc. They have differing perceptions of water dynamics and choose various strategies to cope with problems while trying to achieve their own objectives. Consequently, the number of social conflicts related to water usage is increasing.

A 3-year project entitled "Companion modeling for resilient water management: Stakeholders' perceptions of water dynamics and collective learning at the catchment scale" was submitted to the Consultative Group on International Agricultural Research (CGIAR) Challenge Program on Water and Food and funded in 2005. The project deals with conflicts regarding access to water among farmers and villages in Bhutan, tensions over water use between upstream and downstream communities in northern Thailand, conflict between agricultural intensification and labor migration in lower northeast Thailand, and conflict between rice producers and shrimp growers in southern Vietnam. These conflicts and their consequences are so important that they are very frequently reported in the national and international media. To mitigate them, new legislative frameworks on decentralized water resource management are being prepared in many countries. Once the management approach is decided, its success depends on the quality

of local coordination among stakeholders, who often lack tools, methods and trained managers to minimize conflicts. Consequently, there is demand for innovative approaches and tools to improve coordination processes at the watershed level among an increasing number of diverse stakeholders using common water resources.

Bousquet F., J.C. Castella, B. Ekasingh, C.T. Hoanh, S. P. Kam, H. Manichon, D.V. Ni, D.D. Quang, G. Trébuil, and T.P. Tuong. 2006. Ecoregional Research for Integrated Natural Resource Management in Southeast Asian Rice Ecosystems. In *France and the CGIAR: Delivering scientific results for agricultural development*. pp. 80-84.

With resource management becoming decentralized in many Asian countries, new methods and capacities are needed to support truly interdisciplinary action research in the field of integrated natural resource management (INRM) to facilitate the empowerment of stakeholders. Stakeholders need access to knowledge, understanding of the problem at hand, skills and tools to facilitate communication and negotiation, and the capability to articulate their differing objectives, negotiate their demands, and finally adopt and adapt appropriate interventions at the right scale. The main research challenge is to generate pertinent INRM knowledge and the tools for using it, and to facilitate their free exchange among researchers, policymakers, managers and resource users. This paper highlights the characteristics of promising methodologies and several results obtained through collaborative research.

The three goals of the Consultative Group on International Agricultural Research (CGIAR) — alleviating poverty, increasing food security and protecting the environment — recognize that human well-being depends on the well-being of the systems in which people earn their living. This means recognizing that the livelihood concerns of farmers are closely linked with the status of their renewable resource base and that the resilience of their production systems depends on their adaptive capacity to manage it. To support the sustainable development of a given region, the comprehensive system composed of the land, its people and their activities must be researched. Past research has demonstrated that, to improve livelihoods while ensuring the sustainability and resilience of the resource base, one needs to understand and harness the interactions among policies, institutional settings and human behavior, as well as between human activities and biophysical processes.

The decentralization of resource management is under way in many Asian countries. Methodological development and capacity building are needed to support truly interdisciplinary action research in the field of integrated natural resource management (INRM) to facilitate the empowerment of stakeholders at various levels. To make informed decisions, stakeholders need access to knowledge, understanding of the problem at hand, skills and tools to facilitate communication and negotiation, and the capability to articulate their differing objectives, negotiate their demands, and finally adopt and adapt appropriate interventions at the right scale.

As INRM and environmental problems become more complex, innovative approaches, methods and tools are becoming available to deal with the adaptive management of these systems. An interdisciplinary systems perspective needs to be adopted to tackle the various dimensions of integration in INRM across disciplines and sources of knowledge, geographical and time scales, and the research-development-policy continuum.

The main research challenge is to generate pertinent INRM knowledge and the tools for using it, and to facilitate their free exchange among researchers, policymakers, managers and resource users. In particular, dynamic and interactive modeling tools can be used in communication platforms to help stakeholders understand and simulate biological, physical and social interactions at various spatial scales and hierarchical levels of social organization. Because the researchers' role is to facilitate empowerment, the emphasis is on developing research and operational methodologies while involving stakeholders and forging partnerships at every stage of the process.

Dung L.C., N. G. V. Nguyen, L. A. Tuan, and F. Bousquet. 2005. Economic differentiation of rice and shrimp farming systems and riskiness: A case of Bac Lieu, Mekong Delta, Vietnam. In F. Bousquet, G. Trébuil, and B. Hardy. (eds). 2005. *Companion Modeling and Multi-Agent Systems for Integrated Natural Resource Management in Asia*. pp. 211-235. Cirad and International Rice Research Institute: Los Baños, Laguna, Philippines.

In production terms, Bac Lieu Province in the Mekong Delta of Vietnam is characterized by rice and saline-water shrimp farming. This paper presents two simulation models of economic differentiation of those farming systems. The first model simulates observed farmers' behavior in six different farming subzones of the province. After simulating 5 years for each farming system corresponding to each subzone, the results showed that economic differentiation has occurred in every subzone at the study site in terms of both household average accumulation of income and number of households in the rich and poor class. The household average accumulation of income of the rich household class in those subzones where physical conditions allowed shrimp farming has a high value, while that of the medium and poor households remains at a low value, and is even negative for two subzones. The household average accumulation of income of the rich household class in those subzones where physical conditions (freshwater zone) allowed only rice farming reaches a high value after 5 years of simulation, but this value is still less than that in shrimp-culture subzones. The poor households in these subzones of rice-based farming also face a negative income after some years. The second model aims at simulating changes in cropping system under various conditions. The individual decision-making process is based on a theoretical model, the Consumat. Scenarios based on alternative values of prices, yields, risk, and size of networks are compared. It is shown that prices and shrimp yields make the difference in terms of both wealth and economic differentiation. The questions raised over time are (1) Is there a differentiation in income distribution at the household level because of the biophysical conditions and market factor? (2) Is there a differentiation in household income within the subzone because of biophysical conditions and heterogeneity in farm management knowledge? (3) How will the differentiation evolve if the farmers change their behavior? In this research, the first two questions are discussed by running a simulation model based on the observations of farmers' decisions for six different zones and the third question is discussed by running a simulation model using a theoretical model of the decision-making process, the Consumat approach (Jager 2000). A multi-agent systems (MAS) model supported by the CORMAS (common-pool resources and multi-agent systems) program helps us to answer those questions. It allows us to visualize the scenarios after linking several biophysical and socioeconomic factors. Consequently, given the complexity of this subject, the spatial characteristics, and, above all, the noneconomic and interactive behavior of farmers, we use the MAS model to simulate the scenarios. This paper presents first the background of the study and a brief review of applications of MAS for water management and economic differentiation. Then, a first model is conceptualized and simulated to explore the consequences of the actual behavior of stakeholders. A second model, more abstract, explores the consequences of the changes in behavior and the relative effects of various driving forces. (Résumé d'auteur)

Lacombe, G. and W. Naivinit. 2005. Modeling a biophysical environment to better understand the decision-making rules for water use in the rainfed lowland rice ecosystem. In F. Bousquet, G. Trébuil, and B. Hardy. (eds). 2005. *Companion Modeling and Multi-Agent Systems for Integrated Natural Resource Management in Asia*. pp. 191-209. Cirad and International Rice Research Institute: Los Baños, Laguna, Philippines.

Growing rainfed lowland rice (RLR) is the main activity in northeast Thailand. Unpredictable droughts and coarse-textured soil are the principal constraints usually

cited to explain the low yields and economic poverty of this region. Past studies tried to improve the drought tolerance of rice varieties and hydrological functioning at the field level. How water is used at the farm level remains largely unknown. Consequently, it is relevant to understand the interactions between the water-resource and water-use dynamics in the RLR ecosystem. This article proposes to develop a simulation tool based on multi-agent systems to explore adaptations of the rice cropping pattern to rainfall variability. An environment containing the main biophysical entities involved in decision-making rules for water use is modeled and its hydrological functioning is verified. Preliminary simulations are run to illustrate the model capacities. These simulations aim at evaluating farm pond capacity to alleviate early drought at the vegetative stage. Simulations comparing scenarios with and without ponds show that ponds are less efficient at the beginning of the RLR cycle, when rains are still light. Pond efficiency is stable when the period separating two seedbed sowings is longer than 2 months. Below this threshold, it is possible that the ponds are not completely refilled. The next step in the model development will consist of adding autonomous agents to simulate scenarios in which farmer agents may cooperate to use water.

Conferences papers:

Barnaud C., F. Bousquet, and G. Trébuil. 2006. Multi-Agent Simulations to Explore Rules for Rural Credit Management in a Highland Farming Community of Northern Thailand. In *Proceedings of The 1st World Congress on Social Simulation*, vol.1: pp. 279-286. In Kyoto, Japan.

Thanks to recent advances in the field of distributed artificial intelligence, agent-based models (ABM) can now be used to run simulations of social phenomena based on their computerized representations, and to apply experimental methods in social sciences (Axelrod 1997, Gilbert and Troitzsch 1999, Jager 2000). In the field of renewable resource management and environmental sciences, several ABM simulation platforms offer the possibility to explore interactions between social and ecological dynamics (Costanza and Ruth 1998, Bousquet et al. 1998, Lansing 2002). In these complex systems, the social and economic dynamics can be viewed as a set of interactions among heterogeneous agents, generating aggregate phenomena that are different from the behaviour of groups of average individuals considered in classical economic thinking (Rouchier and Bousquet 1998). Such a view was adopted in the research presented here.

The agent-based model presented in this paper was built to explore the interrelated roles of formal and informal credit in a socially heterogeneous community of small farmers exploiting a highland catchment of mountainous upper northern Thailand. Formal credit corresponds to institutionalized credit funds whereas informal credit is seen as loans settled among villagers, either without interests within networks of acquaintances, or with high interest rates when loan sharks are involved.

An original characteristic of the companion modelling approach (Bousquet and Trébuil 2005, <http://commod.org>) and the simulation process adopted in this case study is the co-construction of the model with the farmers and the use of simulations with them in their village. The objective was to facilitate collective decision-making regarding the adaptation of the local rules for the allocation of rural credit to allow a more equitable and extensive process of expansion of perennial crops (Barnaud et al. 2005). Following a description of the methodology and tools used in this experiment, the results of a series of multi-agent system simulations are presented and analyzed. To end with, the specific questions and challenges raised by this type of social modelling and simulation process are discussed, particularly its use and usefulness to local stakeholders.

Barnaud C., P. Promburom, F. Bousquet, and G. Trébuil. 2005. Companion modelling to facilitate collective land management by Akha villagers in upper northern Thailand. Paper presented at *the International Conference on "Sustainable Use of natural Resources and Poverty Dialogue in Montane Mainland South East Asia (MMSEA IV)*. May 16-19, in Sapa, Vietnam.

For the last two decades, the highlands of northern Thailand have been the theatre of numerous conflicts dealing with natural resource management (NRM) among an increasing number of stakeholders with different and sometimes contradictories perspectives (Rutherford, 2002). This is due to factors such as development of communication infrastructure, integration to market economy, increasing population density and environmental policies that led to a relative scarcity of farmland and water resources (Bruneau, 2002; Thomas et al., 2002). Two main types of conflicts dominate in upper northern Thailand: water-related conflicts opposing highlanders and lowlanders, and conflicts regarding farmland and forest cover opposing local communities to the State. Highlanders did not have much say in the regulation of these conflicts so far. Their actions were considered to harm the environment and the government highly restricted their access to natural resources. As a result of these decades of highly centralized NRM, not only did degradation of environment continue, but many communities dependent on natural resources were impoverished (McKinnon et al., 1989; Suwannarat, 1995).

In Thailand, as in other countries of Southeast-Asia, the recent general policy-making framework regarding (NRM) is favoring decentralization and public participation. This is an important opportunity for local communities to regain control over NRM and to increase their say in public affairs (Neef et al., 2000; Ganjanapan, 2002). During the last decade, participation became a key word in numerous projects, but most of them adopted participation as a mean, and not as a goal (Hirsh, 2002; Neef et al., 2003). Therefore much effort is still needed to really enable local stakeholders to participate in local NRM. But the eco-sociosystems that they have to manage are complex and uncertain, with numerous interacting ecological, social and economic dynamics and an increasing number of stakeholders with different socio-economic interests, land-use strategies and points of view (Rerkasem et al., 1994; Trébuil et al., 1997).

There is a need to develop innovative and context-adapted methodologies and tools to enable the various local stakeholders to identify and rank their key problems by themselves, to exchange their points of view on these problems, and to reflect collectively on ecologically adapted and socially acceptable solutions in such agrarian situations. Companion Modelling (ComMod) is an emerging approach designed to facilitate collective action at the community level. It is combining Multi-Agent Systems (MAS) and Role-Playing Games (RPG) to facilitate dialogue between various stakeholders concerned by a given local NRM issue (Bousquet et al., 1999).

Since late 2002, such a ComMod process is being tested in an Akha village of upper northern Thailand to promote collective watershed management, and particularly to examine the interactions between soil and water conservation, agricultural diversification, and social equity. Following a presentation of the context & problem, and of the original characteristics of the ComMod approach, this article describes its concrete use with Akha villagers. The article explains the way a shared representation of the watershed and its dynamics is achieved, and the way it supports collective learning on land management. The flexibility and adaptive characteristics of the gaming and simulation tools used with the people will be highlighted as they fit with the evolving nature of coordination processes in adaptive NRM. Finally, preliminary lessons from this ComMod experiment are presented as well as new perspectives for improving this approach.

Barnaud C., P. Promburom, G. Trébuil, and F. Bousquet. 2008. Interactive models to catalyze collective water management: a companion modeling approach in northern Thailand. In *Proceedings of the 2nd International Forum on Water and Food (IFWF2)*, CPWF-CGIAR, November 16-18, in Addis Ababa, Ethiopia.

How can simple interactive models catalyze collective learning and action about local water management? This paper aims at providing an answer to this question by drawing on a Companion Modeling (ComMod) experiment on irrigation water sharing in a highland community of Northern Thailand. In a ComMod process, simulation models integrating different stakeholders' points of view on the problem at stake are developed and used as communication platforms to facilitate the collective exploration and assessment of various possible future scenarios. In this case study, the ComMod process combined a preliminary diagnostic-analysis of the heterogeneous socio-political context, a Role-Playing Game (RPG) and an associated simple Agent-Based Model (ABM). An ABM was used to run simulations to stimulate a plenary debate and, later on, to facilitate discussions within small homogeneous groups of farmers. The various effects of the process on the participants in term of learning, communication, behavior change, and new practices were evaluated through series of individual interviews. This ComMod process stimulated individual and collective learning and coordination among multiple stakeholders exploring pathways to solve their common irrigation water use problem. We show that in participatory modeling, simple models can be useful to mediate water use conflicts and accommodate multiple interests among stakeholders. To do so the participatory aspects of the modeling and simulation process must be carefully managed. In particular, much attention needs to be paid to the initial socio-political context and its power inequities to ensure the genuine involvement of all concerned stakeholders, including the usually voiceless and resource-poor ones.

Barnaud C., T. Promburom, G. Trébuil, and F. Bousquet. 2006. Companion modelling to support collective land management in the highlands of northern Thailand. In S. Laohasiriwong and M. Ang (eds.), *Proceedings of the International Conference on Natural Resources Related Conflict Management in Southeast Asia*. pp. 90-112. September 6-8, 2005, in Khon Kaen, Thailand.

For the last two decades, the highlands of northern Thailand have been the theatre of numerous conflicts dealing with natural resource management among an increasing number of stakeholders with different and sometimes contradictory perspectives. These conflicts mostly originate over an increasing scarcity of farmland and water resources, which is due to factors such as increasing population density, integration into the market economy, and environmental policies. Two main types of conflicts dominate in upper northern Thailand: water-related conflicts between highlanders and lowlanders, and conflicts regarding farmland and forest cover, with local communities opposing the State. Highlanders did not have much say in the regulation of these conflicts so far. Their agricultural practices were considered harmful to the environment and the government highly restricted their access to land and its management. As a result of several decades of highly centralized natural resource management, not only did degradation of environment continue, but many communities dependent on natural resources were impoverished.

In Thailand, as in other countries of Southeast-Asia, the recent general policymaking framework regarding natural resource management is favouring decentralization and public participation. This is an important opportunity for local communities to regain control over natural resource management and to increase their say in public affairs. During the last decade, participation became a key word in numerous projects, but most of them adopted participation as a means, and not as a goal. Moreover, they were often based on a so-called "ethno-romantic" view of hill tribe communities and failed to take into account diversity and divergence of points of view among stakeholders within local communities. Therefore, much effort is still needed to enable the various local stakeholders to participate genuinely in local natural resource management issues. However, their eco-sociosystems are complex and uncertain, with numerous interacting ecological, social, and economic dynamics, as well as an increasing

number of stakeholders with different socio-economic interests, land-use strategies, and points of view.

The general objective of the research activities presented in this paper is to develop innovative and context-adapted methodologies and tools to enable local stakeholders to identify and rank their key problems, to exchange their points of view on these problems, and to reflect collectively on ecologically adapted and socially acceptable solutions in such agrarian situations. We assume that this can be achieved through the facilitation of a collective learning process. In our work, learning is broadly defined as a change in the way people perceive their social and ecological environment (and consequently the way they act on it), according to their experiences, beliefs, values, intentions, and interactions with other people. Companion Modelling (ComMod) is an emerging approach designed to facilitate collective learning and action at the community level. In most cases, it is combining the use of Multi-Agent Systems and Role-Playing Games to facilitate dialogue between various stakeholders concerned by a given local natural resource management issue.

Since late 2002, such a ComMod process is being tested in Mae Salaep, an Akha village of upper northern Thailand, to promote collective catchment management. This research takes place while highlanders are accused by lowlanders of continued deforestation and accelerated soil erosion in the head watersheds, and of disturbing the functioning of whole watersheds through sedimentation in rivers and reservoirs, as well as flash floods in downstream areas. In the past, numerous development projects attempted to solve this problem by proposing technical erosion control measures to farmers. Most of these attempts failed because of a lack of compatibility with local farmers' practices and strategies. The initial objective of the ComMod process was to stimulate collective learning on the soil erosion problem at the community level in Mae Salaep village. In particular, it aimed at examining the interactions between soil and water conservation, agricultural diversification, and social equity with the local stakeholders.

Following a presentation of the local context, the problem, and the original characteristics of the ComMod approach, this article describes its concrete use with Akha villagers. The article explains how a shared representation of the watershed and its dynamics is achieved, and the way it supports collective learning on land management. The flexibility and adaptive characteristics of the gaming and simulation tools used with the people are highlighted as they fit with the evolving nature of coordination processes in adaptive natural resource management. How the focus of discussions evolved from agroecological to socio-economic dynamics related to soil erosion issue is also explained. Finally, preliminary lessons from this ComMod experiment are presented, as well as new perspectives for improving this approach.

Barnaud, C., P. Dumrongrojwattana, J. Marie, C. Le Page, and G. Trébuil. 2006. Initial diagnostic analysis for companion modelling to accommodate multiple interests in upper watershed management. In *Proceedings of the 2nd NAFRI International Conference on Sustainable Sloping Lands and Watershed Management (SSLWM)*, pp. 317-335. In Luang Prabang, Lao PDR.

Ethnic minorities in the highlands of Northern Thailand have long been accused of degrading the upper watersheds of the country's major basins. During the past three decades, the impressive amount of agronomic research carried out to study ways to control soil erosion in the sloping highlands had limited success. The introduced standard "technological packages" were not adapted to local farming systems, and therefore were not widely adopted (Turkelboom and Trébuil 1998). In the meantime, environmental policies were reinforced. In the 1990s, the government further restricted highlanders' access to farm land through the delimitation of reserved forest areas managed by the Royal Forestry Department, and the establishment of many new National Parks, Wildlife Sanctuaries, etc. (Hirsch 1997). This resulted in an increasing number of conflicts over land-use between local communities and state agencies. The limits of past research and

policies in the field of soil and water conservation call for more integrated transdisciplinary and truly participatory approaches to better balance between agro-ecological and social aspects of collective management issues to be examined and mitigated (Sayer and Campbell 2003).

Drawing the lessons from the numerous participatory watershed management projects conducted in the past, more and more authors argue that because of a lack of attention to the complex political contexts in which these projects were embedded, the less powerful stakeholders were often left behind (Wollenberg, Anderson et al. 2001). This issue has drawn a dividing line among scholars. Two main attitudes may be typified: a "dialogue" vision and a "critical" vision (Faysse 2006). According to the proponents of the dialogue vision, the main obstacles to fruitful coordination stem from a lack of genuine communication among stakeholders. Once this barrier is removed, it is possible to build a common vision, and to achieve consensus (Röling and Wagemakers 1998). On the contrary, proponents of critical vision argue that power relations need to be addressed first, otherwise there is a high risk that the participatory process deepens the existing social inequities (Edmunds and Wollenberg 2001).

The question we address in this communication is: how far is a preliminary institutional analysis needed prior to the launch of a collaborative modelling process? This question is addressed drawing on a Companion Modelling (ComMod) experiment being conducted in Nan province, Northern Thailand, about a conflict between two Mien communities and a National Park. The objective of the ComMod approach is to stimulate collective learning and coordination among multiple stakeholders to solve a common problem of renewable resource management (Bousquet, Trébuil et al. 2005). Its principle is to develop simulation models integrating different stakeholders' points of view on the problem at stake, and to use them to explore and discuss collectively various scenarios for the future. The objective of this communication is to demonstrate the importance of an initial institutional analysis prior to the ComMod process per se. We argue that this initial analysis of stakeholders social status, perceptions of the problem at stake, social relations and interactions is needed to: (i) identify the feasibility and the usefulness of a ComMod process, (ii) identify the constraints towards equitable outcomes of the participatory process (who is likely to benefit?), and provide means to adapt the ComMod process to mitigate them, (iii) get a picture of the initial stakeholders' perceptions and interactions to be used as a baseline to assess the effects of the ComMod process in terms of communication, collective learning and coordination mechanisms.

After a presentation of the conceptual framework used to analyse the situation and its changes, and the ComMod process being implemented, we will present the results of the initial diagnosis and how they were used to tailor the on-going ComMod process. The preliminary results of the ComMod process in terms of accommodation of multiple interests are also presented and discussed. In conclusion, the authors describe how they are used to define the next steps of the collective learning process.

Barnaud, C., P. Promburom, T. R. Gurung, C. Le Page, and G. Trébuil. 2006. Companion Modeling for collective learning and action in water management: Lessons learnt from three case studies in northern Thailand and Bhutan. Presented at *the International Symposium Towards Sustainable Livelihoods and Ecosystems in Mountainous Regions*, March 7-9, in Chiang Mai, Thailand

The purpose of the interdisciplinary Companion Modelling (ComMod) approach in renewable resource management is to facilitate collective learning, negotiation, and institutional innovation about concrete problems faced by rural communities. The objective of this communication is to present and to compare the effects of the ComMod approach on collective water management at three different pilot sites located in upper northern Thailand (two sites) and west-central Bhutan. At these sites, water management is a cross-cutting problem: the processes of agricultural commercialization and increased pressure on the land led to the need for stakeholders to agree on new

rules for the management of limited water resources. In the Lingmutyechu watershed of Bhutan, water sharing at rice transplanting has been a perpetual issue, without a way forward, while in montane northern Thailand a looming water scarcity is linked to the increased demand from expanding irrigated horticultural cropping systems.

The paper compares the way this approach was flexibly adapted and implemented at the three sites according to the local contexts. The main effects of the ComMod process at the three sites are then presented according to a common framework analysing the processes of collective learning, negotiation, and coordinated action that were stimulated. It emphasizes the following effects : learning about the current situation and awareness of a problem to be solved collectively, understanding each other's perceptions and common agreement on the nature of the problem, exploration of new management rules to solve the problem, and concrete implementation of institutional innovation. The discussion focuses on the factors contributing to, or limiting, the achievement of institutional innovation. The role of the local institutional context and the possibility to establish inter-institutional dialogue among multiple levels of organization is highlighted. Finally, we point out the need for specific monitoring & evaluation procedures adapted to such a highly participatory and adaptive process.

Barnaud, C., T. Promburom, G. Trébuil, And F. Bousquet. 2007. Using simple models to accommodate multiple interests in water management: A companion modeling approach. In *Proceedings of the 2nd International Conference on Asian Simulation and Modelling (ASIMMOD): Towards Sustainable Livelihood and Environment*. pp. 248-255. January, 9-11, in Chiang Mai, Thailand.

Decentralization of renewable resource management provides an opportunity for local stakeholders to increase their participation in decisions affecting them. Research should propose adapted methodologies and tools enabling the numerous stakeholders of complex socio-ecosystems to identify and discuss about possible solutions to their common problems. We show that in participatory modelling processes, simple models can be as useful as comprehensive and sophisticated ones to accommodate multiple interests among stakeholders, on the condition that the modelling and simulating process itself is carefully participatory, i.e. pays much attention to the initial socio-political context in which this participatory modelling process takes place to ensure the genuine participation of all concerned stakeholders (including the usually voiceless and resource-poor ones). This assumption is discussed by drawing on a Companion Modelling (ComMod) experiment on water management in a Northern Thailand highland community. The basic principle of the ComMod approach is to develop simple simulation models integrating different stakeholders' points of view on the problem at stake, and to use them in communication platforms to explore and discuss collectively various scenarios for the future. By combining a preliminary analysis of the heterogeneous socio-political context with a very simple Agent-Based Model, a Role-Playing Game, individual interviews, and group debates, this ComMod process was efficient at stimulating collective learning and coordination among multiple stakeholders exploring pathways to solve their common water use problem.

Bousquet F., and G. Trébuil. 2005. Synergies between multi-agent systems and role-playing game in companion modeling for integrated natural resource management in Southeast Asia. In *Proceeding of the International Conference on Simulation and Modeling*, pp. 461-469. January 17-19, in Bangkok, Thailand.

A key challenge in integrated natural resource management (INRM) consists in reconciling ecological and socio-economic dynamics for a collective, sustainable, and equi-table management of the land. Diverse stakeholders have different legitimate points of view and representations of the system they exploit and its management is better seen as a collective learning process.

We have tested a “companion modeling” (COMMODO) approach combining multi-agent systems (MAS) models and role-playing games (RPG) to examine concrete INRM problems with stakeholders. This participatory process consists in repetitive back and forth steps between the model and the field to facilitate dialogue, shared learning, and collective decision-making through interdisciplinary and action-oriented research.

The methodological features of this approach are de-scribed and two applications in rural Thailand are pre-sented. Among the lessons learnt, we argue that COMMODO users need to distinguish between two specific contexts: (i) The production of new knowledge on a given complex system and (ii) Supporting evolving, iterative, and continuous collective decision-making processes. Such MAS-based and bottom-up COMMODO approach offers a great potential where land management policy frameworks encourage the decentralized management of natural resources.

Dumrongrojwattana P., C. Barnaud, N. Gajaseni, and G. Trébuil. 2007. Companion modelling to facilitate adaptive forest management in Nam Haen sub-watershed, Nan Province, northern Thailand. In *Proceedings of the 2nd International Conference on Asian Simulation and Modelling (ASIMMOD): Towards Sustainable Livelihood and Environment*. pp. 327-333. January, 9-11, in Chiang Mai, Thailand.

Forest management through the establishment of headwater management units and the new Nantaburi National Park in Nan Province, northern Thailand, deals with many stakeholders. They have different points of view and interests on forest resource use, different kinds of knowledge, and different opportunity to participate in setting up a management plan. This creates conflicts on forest resource use and management, particularly about the rules for collecting non-timber forest products in the National Park area. This kind of problem is complex not only because it involves many stakeholders, but also because it deals with several interacting ecological and social dynamics. The Companion Modeling (ComMod) approach adopted in this case study seems adapted to facilitate participatory and adaptive management in such complex situations. Roleplaying games, multi-agent systems, and a geographic information system will be used to build a communication platform integrating various points of view, knowledge (scientific and indigenous), and disciplines (social and ecological ones). There are four main iterative phases to be implemented with the stakeholders i.e. i) diagnosis and problem identification, ii) sharing, adjustment, and improvement of knowledge and perceptions on the problem with gaming simulations, iii) collective discussions to generate acceptable scenarios to be tested and agreed-upon indicators for their evaluation, iv) computer simulations to support the collective assessment of these scenarios and decision-making on further action to be taken. The expected outcome of this action-research process is an improved collective planning and management of forest resources and the construction of a generic model that could be adapted to similar situations at other sites. Following a presentation of the forest management problem at the study site, the first implemented steps of the ComMod process are described. The initial diagnosis and the first set of participatory gaming simulations provided the research team with a better understanding of local stakeholders’ needs and perceptions. These preliminary results allow us to precise the subsequent steps based on key resource management problems identified with the stakeholders. In particular models integrating ecological and socio-economic aspects of cattle grazing in the forest and the gathering of non timber forest products will be constructed to facilitate adaptive forest management by various stakeholders, in particular villagers and national park officers.

Dumrongrojwattana P. and G. Trébuil. 2010. Negotiating the forest-farmland interface in northern thailand with companion modelling. Paper presented at *the RCSD International Conference on Revisiting Agrarian Transformations in Southeast*

Asia: Empirical, theoretical and applied perspectives, May 13-15, in Chiang Mai, Thailand. <http://rcsd.soc.cmu.ac.th/ChATSEA/>

The debate about the expansion of agriculture in forest areas and the conservation or reforestation of head watersheds is still going on in montane Southeast Asia but in a rapidly changing context. Tremendous change occurred in the highland agrarian systems of northern Thailand during the past decades, leading to new farming practices, an increased diversity of stakeholders concerned by land management issues, and new relationships between villagers and national policies (decentralisation of resource management, shift from forest exploitation to conservation, etc.) and international conventions. In this context, the debate about the true participation of rural people in managing local renewable resources is taking central stage.

New conceptual and practical tools to understand rural change in a more distributed, inclusive and interactive way have also emerged. System approaches relying on collaborative modelling are used to facilitate communication, knowledge sharing and the exchange of points of view among different types of stakeholders about a common resource management problem. The iterative and evolving Companion Modelling (ComMod) approach relies on multi-agent systems and makes use of the synergistic effects between role-playing games and computer agent-based models to co-construct simulation tools with stakeholders used in the joint exploration of possible future scenarios of their choice as part of negotiation processes leading to concrete action plans.

In the past three years, such a ComMod process has been implemented in the head watershed of Nan province to understand the effects of recent change in forest management on the agrarian system and to mediate a land use conflict between foresters and Hmong herders. A preliminary diagnostic-analysis showed the influence of increased forest conservation efforts on the dynamics of deforestation in the local Hmong agrarian system. These land use dynamics were represented in a spatially explicit computer-assisted role-playing game. This tool was enriched and validated with the herders and foresters during a first set of gaming and simulation sessions aiming at the production of a shared representation of the problem at stake. The debate that followed identified innovative cattle management techniques to be tested and the simulation tool was modified to accommodate them. A second set of collaborative simulations tested the use of these innovations and led to an agreement on a joint experiment between herders and foresters seen as a first concrete step toward the co-management of the local forest–farmland interface.

These results are discussed and the relevance of the approach, as well as the strengths and limitations of its main tools are assessed. Finally possible methodological improvements are suggested for collaborative modelling and simulation to better support the emergence of effective decentralized co-management of renewable resources in similar socio-ecological systems.

Dumrongrojwatthana P., C. Le Page, N. Gajasen, and G. Trébil, . 2009. Co-constructing an agent-based model to mediate land use conflict between herders and foresters in northern Thailand. In *Proceedings of the 24th Annual Landscape Ecology Symposium, Landscape Patterns and Ecosystem Processes*. p 55. April 12-16, in Utah, USA.

Landscape dynamics are driven by complex interactions among ecological, social, economic, and policy factors. In conservation areas, these factors are usually related to an increasing number of diverse land resource managers and users. Land use conflicts occur frequently because they have different interest, objectives and perceptions of landscape resources and their use. Sharing these different, but all legitimate, perceptions of the landscape and its use among concerned stakeholders is a pre-requisite for better collective land management, particularly in conservation areas. This research is using the integrative companion modeling approach to co-construct an

agent-based model representing the dynamic interactions between vegetation dynamics, reforestation efforts, and livestock grazing in the upper watershed of Nan province, northern Thailand. The paper focuses on the participatory modeling process implemented with local stakeholders at this site. Three main investigation tools were used to exchange and gather knowledge on ecological and human decision making processes: field surveys (land use history and analysis of vegetation dynamics at the landscape level), farmers' interviews (analysis of individual decision making and determining factors across different farm types), and institutional analysis in relation with changes in land use policy and related state interventions. This knowledge was first assembled in simple gaming exercises presented to local herders and foresters to further enrich and validate the researchers' understanding of key interactions regulating vegetation and land use dynamics. The outputs of these collaborative modeling activities were used to design a hybrid agentbased hybrid simulator blending a role-playing game and a computer program developed under the CORMAS platform. This simulation tool, representing the complex human and ecological interactions at the landscape level, allowed stakeholders to criticize and improve this comprehensive formalization of the landscape dynamics. It was also used to introduce simulation exercises with local stakeholders and to stimulate them to identify possible future land management scenarios mitigating the current conflict.

Dumrongrojwatthana, P., G. Trébuil, N. Gajaseni, and C. Le Page. 2009. Participatory design and use of simplified landscape in simulation model for mitigating land use conflict in Northern Thailand highlands. Paper presented at the *S4 (Spatial Simulation for Social Science) International Conference (Emergence in Geographical Space: Concepts, Methods and Models)*. November 23-25, in Paris, France

Landscape modelling integrating spatial information in Geographic Information Systems has been widely used to represent knowledge and support decision-making in the field of natural resource management. However, creating suitable visual representations of the landscape and its dynamics to stimulate the participation of diverse stakeholders in co-management of the land is still needed. This paper focuses on the design and implementation of a virtual landscape based on iconic representation used with herders and foresters, which both of them have contrasted perceptions on forest regeneration, to observe vegetation dynamics and emerging landscape features depending on different cattle and forest management strategies. This spatial interface was used during computer-assisted Role-Playing Game sessions as part of a Companion Modelling process aiming at facilitating learning and support decision making among the concerned stakeholders in an upper watershed of northern Thailand.

Before designing the spatial interface used in the model, an historical analysis of land use and land cover changes based on remote-sensed data was carried out, as well as a field survey on the impact of cattle grazing on vegetation dynamics. Then, the first set of vegetation states and their dynamics were produced and were validated with herders and foresters later. Thereafter, the simplified landscape representing landscape heterogeneity was constructed and used in two gaming and simulation field workshops. The different patterns of landscape emerged from herders' and foresters' decisions and interactions stimulated them to think about how to manage agro-ecosystems. Both of them agreed to implement a pilot plot of *Brachiaria ruziziensis* pasture in reality after finish the second workshop. This process proved to be instrumental in facilitating communication among the parties in conflict and increasing their motivation to improve the current situation. However, the use of such virtual landscape in gaming sessions proved to be time consuming and the managed area as well as the number of players was limited. Therefore, to get rid of these constraints, a fully autonomous Agent-Based Model making use of the same kind of simplified virtual landscape will be developed and used with local stakeholders to run possible future scenarios of change in a more time efficient and inclusive way.

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Dumrongrojwatthana, P., G. Trébuil, N. Gajasen, and C. Le Page. 2009. Using role-playing game for learning and mitigating land use conflict between herders and foresters in upper Nan Watershed, northern Thailand. *The 1st Delta Research and Global Observation Network Asia Summit: Connecting Great Deltas, Great Rivers and Great Lakes*. June 22-25, in Siem Reap, Cambodia.

In recent years, the Royal Thai Government has decentralized the management of natural resources to local authorities and people. However, land use conflicts between government agencies and village communities still occur as in case of the Doi Tiew, a Hmong highland village. This is due to differences in objectives and perceptions between villagers and government officers including the Nam Khang reforestation unit (NKU) and a national park. Companion modelling (ComMod), which belongs to the family of integrated participatory modelling approaches, is used in this research to; i) understand the interaction among cattle raising, forest regeneration and stakeholders' decision making, and ii) set up a share representation and learning platform for collective and adaptive forest-farmland management. Relevant results from land use change, socioeconomic, and vegetation biomass studies (conceptualization of a state transition diagram) were synthesized into tools for a participatory gaming and simulation workshop to i) improve researchers' understanding of vegetation dynamics through sharing different stakeholders' perceptions, ii) better understand stakeholders' decision-making processes and practices regarding cattle and forest management, and iii) explore stakeholders' needs for further adaptation of the ComMod process. The main gaming tool was a computer-assisted Role-playing Game (RPG). Its spatial interface was simplified from the 2003 classified satellite image. Roles of herder and forester were played by different farmer types of Doi Tiew villagers and NKU foresters, respectively. Four scenarios were run as 'no reforestation in the landscape', 'reforestation without access rule', 'reforestation without cattle in landscape', and 'reforestation with negotiation of access rules between herders and foresters'. Cattle status (fat, normal, thin) and duration of forest regeneration were indicators for debriefing. Individual interviews were conducted to gather more information in relation to gaming sessions. The results showed that gaming and simulation features and tools were not difficult to understand by players although it was the first time for them to take part in such activities. The RPG sessions can be used to validate the state transition diagram by stakeholders and are a powerful tool to facilitate learning, exchanging experiences and knowledge among participants. The existing RPG will be further improved by integrating new cattle management techniques, paddocks rotation and Ruzi (*Brachiaria ruziziensis*) pasture establishment, for conducting next workshop as requested by the players. Moreover, more concerned stakeholders will be involved into this ComMod process, especially government officials in charge of cattle raising, in order to achieve a collective management action plan and to facilitate its implementation.

Dung L. C., Hoanh C. T., Le Page C. and Gajasen N. 2008. Agent-based modeling and simulation of integrated rice-shrimp farming in Bac Lieu province, Mekong delta, Vietnam. Paper presented at *the 2nd International Forum on Water and Food*, November 10-14, in Addis Ababa, Ethiopia.

Shrimp aquaculture is economically profitable to coastal people in the Mekong Delta, Vietnam. Nevertheless, conflicts are arising between shrimp and rice farmers from environmental and socioeconomic impacts of shrimp aquaculture. For example, shrimp farming encroaches upon land previously devoted to rice cultivation. This study aims at integrating and sharing knowledge about the rice-shrimp farming system in Bac Lieu Province. Companion modeling (ComMod) was used to involve stakeholders in the construction of a simulation model and discuss its outputs. The first stage of the modeling process consisted of a role-playing game (RPG) in which farmers from two villages in the province recreated their farming decisions. The process revealed diverse water and land-use strategies. In the second stage, agent-based modeling (ABM) used a

subset of individual farming decisions to parameterize a generic model of integrated rice-shrimp farming. The initial ABM scenario spatially generated production areas and water salinity patterns similar to the ones used during the RPG sessions. This similarity is expected to convince farmers of the accuracy and value the ABM analysis, and help create continued interest when requested to 'validate' it by providing user feedback on its features and rules. Additional scenarios based on different sluice operators decisions, risk, and economic conditions were collectively simulated and assessed.

Dung, L.C., C. Le Page, and C.T. Hoanh. 2007. Participatory simulation of competing aquacultural and agricultural land uses in Bac Lieu Province, Mekong Delta, Vietnam". In *Proceedings of the 2nd International Conference on Asian Simulation and Modelling (ASIMMOD): Towards Sustainable Livelihood and Environment*. pp. 313-318. January, 9-11, in Chiang Mai, Thailand.

Rice and black tiger shrimp (*Penaeus monodon*) are produced in coastal area of the Mekong, Vietnam under different patterns depending on biophysical and social economic conditions. In the north part of Bac Lieu province in the Mekong Delta, competitions for land used among these farming systems have been appeared. Rice and shrimp rotation farming has been gradually encroached by shrimp monoculture due to its higher economic return. Monoculture of shrimp in a large scale however would hardly reach sustainability. This study aims to make explicit the criteria used by local producers in choosing their land use. To collectively discuss about these criteria and to build a common understanding of this complex agro-hydro system, we have been using roleplaying games (RPGs). Three RPG sessions have been organized in three selected villages in Bac Lieu coastal province in the Mekong Delta (i) to understand the competition of land used between rice and shrimp production at a village level; (ii) to understand decision making of farmers under complex biophysical and socio-economic conditions. By playing their own role during a RPG session, local farmers are embedded in participatory simulation. Following the companion modeling approach, the next methodological step will consist in implementing an agent-based model to formalize the shared representation that was built during RPG sessions. Local farmers are then expected to be comfortable in following and discussing computer simulations as they will be able to relate the "agent-based simulations" to what they have experienced as participants of "players-based simulations" (the RPG sessions).

Gurung T. R., P. Promburom, W. Naivinit, M. Thongnoi, C. Barnaud, and G. Trébuil. 2008. Effects of companion modeling on water management: Comparative analysis across five sites in Bhutan and Thailand. In *Proceedings of Second International Forum on Water and Food (IFWF2)*, CPWF-CRIAR, November 16-18, in Addis Ababa, Ethiopia.

The trans-disciplinary companion modeling (ComMod) approach for adaptive renewable resource management aims to facilitate knowledge integration, collective learning, creative negotiation, and institutional innovation about concrete problems faced by communities. In this paper, we compare the effects of different ComMod processes on collective water management located at five sites located in northeast and northern Thailand, and west-central Bhutan. At the three highland sites, agricultural commercialization leads stakeholders to review the local water management rules while in Northeastern Thailand land/water management dynamics are interlinked with labor migrations and the market integration of farming activities. The main effects of the ComMod processes at these sites are analyzed based on a common framework focusing on the stimulated processes of individual and collective learning, communication, negotiation, and coordinated action. The following effects are documented: individual learning about current situation, increased awareness of a collective problem, understanding each other's perceptions, reaching a common agreement on the problem,

exploration of new water management rules, implementation of new practices, and institutional innovation. The discussion focuses on how methodological choices made in implementation of ComMod influenced the observed effects. The factors contributing to, or limiting, the achievement of institutional innovation are underlined, in particular the role of the local institutional context and the possibility to establish inter-institutional dialogue among multiple levels of organization are highlighted. Finally, we point out the need for specific monitoring and evaluation procedures adapted to such highly interactive and adaptive processes.

Hoanh C. T., C. Le Page, O. Barreteau, et al. 2008. Agent-based modeling to facilitate resilient water management in Southeast and South Asia. In *Proceedings of the 2nd International Forum on Water and Food (IFWF2)*, CPWF-CRIAR, November 16-18, in Addis Ababa, Ethiopia.

Water is used and managed by stakeholders at different levels for diverse objectives, therefore understanding decision making and supporting coordination is crucial in achieving resilient water management. Companion Modeling (ComMod) is an interactive process facilitated by evolutionary models for knowledge generation and exchange, and for supporting collective decision-making. Role-playing games and computerized multi-agent simulations for focused group debates are complementary tools combined in a ComMod cycle and used at the field workshops. Agent-based modeling is used to understand how different processes in direct competition are coordinated, and to mediate the collective search for acceptable solutions to conflicting parties facilitated through exchanges. This paper compares the process of agent-based modeling applied in eight case studies with diverse natural and socio-economic conditions and different resource management problems in Bhutan, Thailand and Vietnam to show the creative thinking in developing and applying flexible ComMod modeling tools and provide lessons for their use in other situations.

Lacombe G., F. Bousquet, M. Kuper, C. Boonmun, S. Phuphak, W. Naininit, C. Vejpas, and G. Trébuil. 2005. How farmers can manage variability in the rice ecosystem of northeast Thailand? The contribution of agent-based modelling. In *Proceeding of the International Conference on Simulation and Modeling*, pp. 345-352. January 17-19, in Bangkok, Thailand.

Growing rice is the main activity in northeast Thailand. Unpredictable droughts and coarse-textured soil are the principal constraints usually cited to explain the low yields and economic poverty of this region. Past studies tried to improve the drought tolerance of rice varieties and hydrological functioning at the field level. How water is used at the farm level remains largely unknown. Consequently, it is relevant to understand the interactions between the water-resource and water-use dynamics. This article proposes to develop a simulation tool based on multi-agent systems to explore adaptations of the rice cropping pattern to rainfall variability. An environment containing the main biophysical entities involved in decision-making rules for water use is modeled and its hydrological functioning is verified. Preliminary simulations are run to illustrate the model capacities. The next step will consist of adding autonomous agents to simulate scenarios in which farmer agents may cooperate to use water.

Naivinit W., and G. Trébuil. 2006. Using companion modeling to understand interactions between water dynamics and labor migrations in lower northeast Thailand. In *Proceedings on CD-rom of the 3rd Asia Pacific Association of Hydrology and Water Resources (APHW)*, October 16-18, in Bangkok, Thailand.

The human environment interaction influences the natural resource management. It needs to be clarified and understood by concerned stakeholders to ensure practical development. In lower northeast Thailand, the interaction between water dynamic of rainfed lowland rice ecosystem and labour migration plays a crucial role in shaping this agricultural community. Farmers' decision-making processes with regard to on-farm activities are generally determined by water and labour availability. The Royal Thai Government has been trying to alleviate the climatic risk by building small-scale water retentions but the impact is still limited. In this research, an innovative approach, Companion Modelling (ComMod), is used to build collective comprehension regarding such interaction via an associated key tools, Role-Playing Game (RPG) and Multi-Agent Systems (MAS) model with stakeholders throughout the research process. A comprehensive knowledge of interactions and representation of system components would help to design more adapted investments. Therefore, this research aims at understanding and modelling the interactions between water dynamics, land use, and labour migration. The hydrological model was built to represent the water balance, soil properties, and land-use types. Based on the initial conceptual model, rule-based social agents are implemented to represent the decision-making processes of heterogeneous stakeholders regarding farm and off-farm employment. The paper shows how a MAS model is used for collective discussion and scenario exploration with the stakeholders. The results of the game sessions and their use for improving the model are also presented. Finally the results of the simulation of a baseline scenario are discussed.

Naivinit W., C. Le Page, M. Thongnoi, and G. Trébuil. 2008. Agent-based modeling of the interaction between water and labor availability in rainfed rice ecosystem, northeast Thailand. In *Proceedings of the 2nd International Forum on Water and Food (IFWF2)*, CPWF-CRIAR, November 16-18, in Addis Ababa, Ethiopia.

An Agent-Based Model (ABM) was co-designed with local rice farmers to represent the human-environment interactions between land/water use and labor management. A rainfed area of Ubon Ratchathani Province, Thailand was the study site. This ABM evolved along a Companion Modeling (ComMod) process to integrate the research team's scientific point of view with the local farmers' desired development outcomes. The model consists of four interacting components: Climate, Hydrology, Household, and Rice. The "Household" is a rule-based agent that makes daily decisions on the different stages of rice production including water and labor availability. Four main rice decision-making processes are modeled: i) nursery establishment, ii) transplanting, iii) harvesting, and iv) post harvest decisions including labor migration. The toposéquence of lower to upper paddies and types of land use (water bodies, human settlement, paddy fields) are defined in model's spatial settings. The paper describes the structure of key decision-making algorithms implemented in this ABM. The participatory use of this model to facilitate the discovery and assessment of different water and labor availability scenarios is also explained. The impact of such scenarios on farming practices and labor management is also analyzed and discussed.

Naivinit W., C. Le Page, M. Thongnoi, and G. Trébuil. 2008. Improving farmers' adaptive capacity to manage water dynamics through participatory agent-based modelling and simulation in Northeast Thailand. Presented at the *13th World Water Congress 2008 - Global changes and water resources: Confronting the expanding and diversifying pressures*. September 1-4, in Montpellier, France.

Northeast Thailand has the largest rainfed lowland rice (RLR) ecosystem in the kingdom and is notoriously known for its high rate of poor smallholders. The low and unstable rice productivity as a consequence of an unfavourable agro-ecological environment drives resource-poor farmers to migrate and look for more profitable employment. Labour migration is an adaptive strategy practiced by local farmers to cope with climatic uncertainty. But the relationship between labour migration and land and water management on the farms is still poorly documented.

Therefore, we used the Companion Modelling (ComMod) approach to improve the understanding of this key interaction and to reinforce stakeholders' adaptive capacity to deal with uncertainty linked to water dynamics and labour management in the Lam Dome Yai watershed of Ubon Ratchathani Province. The cyclic ComMod process is made of iterative loops comprising field investigations, modelling, and participatory simulations relying on combinations of Role-Playing Games (RPG) and Agent-Based Models (ABM) used with stakeholders.

In this case study, five ComMod loops were carried out to better understand the problem being examined, stimulate exchange of points of view among stakeholders and enhance the creativity of the participants while lessening the black box effect of computer models. The RPG mainly helped the stakeholders to understand the features, rules and operation of ABM simulations. The ABM helped the stakeholders to better understand their situations and to examine the causes of other players' actions. After its validation by the users, the ABM will also be used for discovery learning by exploring possible future scenarios selected by the local farmers.

Naivinit, W., C. Le Page, M. Thongnoi, G. Trébuil, and N. Srisombat. 2007. Use participatory modeling to validate and build multi-agent system model regarding rainfed lowland rice and labor management in Lower Northeast Thailand. In *Proceedings of the 2nd International Conference on Asian Simulation and Modelling (ASIMMOD): Towards Sustainable Livelihood and Environment*. pp. 306-312. January, 9-11, in Chiang Mai, Thailand.

The Lam Dome Yai watershed is a drought-prone area dominated by the rainfed lowland rice (RLR) ecosystem. It is also a homeland of the poor and the only recourse for better livelihood is to migrate to cities. Poverty and labour migration are a result of the interaction between agro-ecological constraints such as erratic rainfall distribution, lack of irrigation and poor soil quality, and socioeconomic dimensions such as economic disparity. In this research, decision-making process of stakeholders regarding farm and labour management is a key to better understand such interaction. A participatory modeling approach like Companion Modeling (ComMod) can be used to understand stakeholders' decision-making process and acquire the mutual recognition of different points of view on a given problem to build a comprehensive knowledge. It is very important to take this knowledge into account for successful investments when the sustainable livelihood of this local community is targeted. In this experiment, we aim at modeling the interaction between land/water use and labour management on different types of RLR farms. The results of three successive participatory modeling workshops using combined-tool, Role-Playing Game (RPG) and Multi-Agent Systems (MAS) model, are presented. The results indicate that the diversity of farms plays an important role to alleviate the labour scarcity. An improvement of water availability is likely to affect only small holders in terms of more farm intensification and fewer migrants. The perception of water availability in farmponds and the use of water are different based on rainfall situation and farmer's means of production. However, a similar rice-growing practice

emerged as a collective agreement among players when a community pond was introduced into the RPG.

Promburom P., and F. Bousquet. 2008. Role-playing games and institutional engagement for modeling land and water management in a northern Thailand watershed. In *Proceedings of the Second International Forum on Water and Food (IFWF2)*, CPWF-CRIAR, November 16-18, in Addis Ababa, Ethiopia.

The paper illustrates implementation of the companion modeling (ComMod) approach to explore stakeholders' interaction in managing land and water resources in a highland watershed in Northern Thailand. Increased crop production in upstream areas led to more frequent water shortage and conflict among water users living at different elevations. Role-playing games (RPGs) were played by resource users to facilitate their mutual understanding on individuals behavior contributing to land and water resources management and its collective outcome. The RPGs effectively stimulated the players to respond to certain constraints and collectively solve the management problems that emerged from the gaming sessions. Players and local key informants interviews revealed common concern toward water shortage and management conflict. Successive co-organizing and facilitation of local and inter-institution's activities to investigate and resolve the water management problems unveiled the characteristics of key actors and their interactions. These findings were used to construct an agent-based model (ABM) representing decision-making process of stakeholders managing land and water resources. It is composed of individual and social group agents, and the watershed environment including land, forest and water resources. Agents can observe, communicate with other agents and interact within this environment. Management scenarios combining various land, forest and water management practices were developed. Using this participatory modeling process, problem awareness, perception change and institutional engagement were obtained.

Ruankaew N., C. Le Page, N. Gajasen, C. Barnaud, A. van Paassen, and G. Trébul. 2008. Companion modelling for integrated renewable resource management: A new collaborative research approach to create common values for sustainable development. Paper presented at *the 2nd ISC2008 Conference*, August 20-22, in Basel, Switzerland.

The sustainable management of renewable resources is often complicated by the diversity and dynamic nature of the ecological and socio-economic systems involved. As the dynamics and interactions of these systems are highly complex and frequently unpredictable, there is a need to opt for transdisciplinary research addressing adaptive and integrated management of renewable resources. Companion modelling (ComMod) is a multi-agent systems (MAS)-based approach relying on synergistic effects between role-playing games (RPG) and agent-based models (ABM) to facilitate collective information sharing and learning, and to improve coordination among stakeholders for negotiation and decision-making. The iterative and adaptive sequences of fieldwork with modelling activities allows the mutual and interactive participation of stakeholders during the design, implementation, calibration and validation steps of the models, as well as exploration of possible scenarios. ComMod was implemented in a study of the conflict between two ethnic communities and a newly proposed national park in Northern Thailand. Deforestation, biodiversity conservation and the livelihoods of the villagers were key issues discussed during RPG sessions with small groups of participants, and subsequently represented in an ABM simulator used with a larger audience. Consequently, the local stakeholders learned about agro-ecological and socio-economic dynamics and gained an increased awareness of these key issues. Mutual understanding was improved, and the importance of collaborative discussion, essential to negotiations

and decision-making, became obvious. Finally, this Northern Thailand experience has shown that collaborative interactions mediated by ComMod were supportive of improved communication and joint learning for the adaptive and integrated sustainable management of renewable resources.

Trébuil G, and Commod Group. 2008. Companion modelling for resilient and adaptive social agro-ecological systems in Asia. In *Proceedings of the 4th National Agricultural Systems Conference: Agricultural for Community and Environment Ready to Handle Climate Change*. pp. 90-104. May 27-28, in Chiang Mai, Thailand.

The Companion Modelling (ComMod) approach for renewable resource management (RRM) is a highly interactive collaborative modelling process used by researchers and local stakeholders to co-construct a shared representation of a given complex issue, and to use it to explore possible solutions of their choice through simulations. The scientific posture of the ComMod researcher creates an original relation between him, the models he develops, and the field actors and circumstances. By considering him/herself as part of the system under study, the researcher is one stakeholder among others in such action research process.

ComMod main objectives are (i) to better understand a complex agro-ecosystem through the collaborative construction and joint use of different types of simulation models integrating various stakeholders' points of view, and (ii) to use these models within platforms for collective learning to facilitate multiple stakeholders' coordination and negotiation processes leading to the definition of agreed upon collective action plans to mitigate their common RRM problems.

The ComMod approach relies very much on the use of Multi-Agent Systems (MAS) combined in various ways with Role-Playing Games (RPG) to facilitate Integrated RRM (IRRM) by focusing on the management of interactions between ecological and social dynamics. A ComMod process alternates lab. modelling and field work phases in an iterative but evolving way, during which its hypotheses and methodology are systematically explicated and regularly questioned and adapted.

Since the introduction of this approach and its tools in 2002, a dozen of ComMod case studies have been developed in the Southeast Asian region, most of them in Thailand. They looked at a broad range of topics ranging from highland catchment management, access to non timber forest products and cattle grazing in forest areas, crop substitution and market integration, land/water use and labour migrations, agro-biodiversity management in a rice seed system, and biodiversity conservation in coastal management.

Following a brief history of the ComMod approach and a short presentation of its theoretical references, its objectives and fundamental principles are introduced. The main phases of a ComMod process, i.e. initialisation, conceptualization, model implementation & validation, scenario exploration, and monitoring & evaluation, are also presented. Finally, the future perspectives for the development of the ComMod approach and the current hot issues being debated are briefly discussed.

van Paassen A., C. Barnaud, and G. Trébuil. 2009. Participatory modelling for renewable resource management - a critical assessment. Paper presented at *the Integrated Assessment of Agriculture and Sustainable Development: Setting the Agenda for Science and Policy (AgSAP)*. March 10-12, in Egmond aan Zee, Netherlands.

The trans-disciplinary companion modeling (ComMod) approach for adaptive renewable resource management aims to facilitate knowledge integration, collective learning, creative negotiation, and institutional innovation about concrete problems faced by communities. In this paper, we compare the effects of different ComMod processes on collective water management located at five sites located in northeast and northern

Thailand, and west-central Bhutan. At the three highland sites, agricultural commercialization leads stakeholders to review the local water management rules while in Northeastern Thailand land/water management dynamics are interlinked with labor migrations and the market integration of farming activities. The main effects of the ComMod processes at these sites are analyzed based on a common framework focusing on the stimulated processes of individual and collective learning, communication, negotiation, and coordinated action. The following effects are documented: individual learning about current situation, increased awareness of a collective problem, understanding each other's perceptions, reaching a common agreement on the problem, exploration of new water management rules, implementation of new practices, and institutional innovation. The discussion focuses on how methodological choices made in implementation of ComMod influenced the observed effects. The factors contributing to, or limiting, the achievement of institutional innovation are underlined, in particular the role of the local institutional context and the possibility to establish inter-institutional dialogue among multiple levels of organization are highlighted. Finally, we point out the need for specific monitoring and evaluation procedures adapted to such highly interactive and adaptive processes.

van Paassen, A., C. Barnaud, and I. Patamadit. 2008. Rethinking participatory action research in renewable resource management. In *Proceedings of the World Congress on Media and Global Divides of the International Association for Media and Communication Research (IAMCR 2008)*. p 203. July 21-25, in Stockholm, Sweden.

Due to the work of Funtowicz and Ravetz, agricultural scientists increasingly recognise the high complexity, diversity, uncertainty, and the high stakes involved in Renewable Resource Management (RNM). Ecological systems as well as social systems are dynamic and interact at various system levels leading to highly complex, non-linear, divergent processes and the emergence of new phenomena. These system dynamics cannot be controlled so adaptive management is needed: reflexive social systems are able to learn and co-evolve in a self-organising manner. Agricultural scientists are called to engage in participatory action research because system dynamics are uncertain so the knowledge difference between scientists and lay people is less relevant, local people have more contextual knowledge about the specific system dynamics, and local people's livelihoods depend (partly) on renewable resources so they have high stakes in the research and the identified solutions. More and more agricultural scientists respond to the challenge and develop methodologies for information sharing and learning such as participatory mapping, participatory scenario analyses, etc.

The key question is: do these efforts actually lead to the intended effect of adaptive management: reflection, self-organisation and institutional change for more sustainable and equitable use of renewable resources? To answer this question, a participatory role-playing-game and simulation experiment, implemented by Companion Modelling (ComMod) practitioners in northern Thailand was studied. The applied methodology, the espoused- and tacit theory-of-change are described based on ComMod documents and articles. Analysing the results with the participants and the designers, it is concluded that the methodology and underlying theories were insufficient to achieve the intended effect.

The ComMod approach primarily focused on learning: the exchange of perspectives to attain a rich picture and mutual understanding. This learning, coupled with the participatory, iterative and multi-level character of the process, was supposed to trigger inclusive negotiation and decision-making. Interviews with the participants revealed that, at the individual level farmers learned about farm and ecological dynamics. Instead of copying other people's farm strategies they now reflect on, and try, new farm practices and strategies. The games and simulation models stimulated mutual understanding and cooperative thinking about collective problems. However, the 12

participants noted they were not able to transfer these insights to fellow villagers. People needed first-hand experience with the ComMod activities to attain similar insights. As a consequence, village level decision-making did not attain the critical mass and momentum needed for collective action. Meanwhile, higher-level administrators/politicians avoided involvement and commitment to the local level learning process. To create change, people have to effectively deal with competing interests, discourses and power dynamics. The theories applied by ComMod did not provide adequate guidance. When launching a participatory action research, process designers need to pay attention to aspects such as empowerment, mobilisation of constituencies and coalitions, and multi-level negotiation.